JOURNAL
OF
DAIRY SCIENCE

VOLUME III

JANUARY, 1920, to NOVEMBER, 1920

PUBLIC LIBRARY
DETROIT MICH

1920
WILLIAMS & WILKINS COMPANY
BALTIMORE, U. S. A.

COPYRIGHT 1921 BY
WILLIAMS AND WILKINS COMPANY

PUBLIC LIBRARY
DETROIT MICH.

CATALOGED

v. 3

EDITORIAL BOARD

J. H. FRANDSEN, *Editor-in-Chief*
Lincoln, Nebraska

BOARD OF EDITORS

A. C. ANDERSON
Lansing, Mich.
F. W. BOUSKA
Chicago, Ill.
C. H. ECKLES
St. Paul, Minn.
E. S. GUTHRIE
Ithaca, N. Y.
H. A. HARDING
Urbana, Ill.
O. F. HUNZIKER
Chicago, Ill.
H. H. KILDEE
Ames, Iowa
C. LARSEN
Brookings, S. D.
C. W. LARSON
Dairy Div. Dept. Agr.
Washington, D. C.
W. P. B. LOCKWOOD
Amherst, Mass.
M. MORTENSEN
Ames, Iowa
LEROY S. PALMER
Columbia, Mo.
FRED RASMUSSEN
State College, Pa.
B. H. RAWL
Washington, D. C.
C. L. ROADHOUSE
Davis, Calif.
L. A. ROGERS
Washington, D. C.
W. A. STOCKING, JR.
Ithaca, N. Y.
M. R. TOLSTRUP
Henderson, Minn.
H. E. VAN NORMAN
Davis, Calif.
R. M. WASHBURN
St. Paul, Minn.
IVAN C. WELD
Washington, D. C.
G. C. WHITE
Storrs, Conn.
W. B. NEVENS
Lincoln, Nebr.

All correspondence regarding articles should be directed to J. H. Frandsen, Editor-in-Chief, Lincoln, Nebraska.

All correspondence regarding advertising should be directed to the Publishers, Williams & Wilkins Company, Baltimore, Md.

CONTENTS

JANUARY. No. 1

Conformation and Its Relation to Milk Producing Capacity in Jersey Cattle. John W. Gowen 1
Experiments With and Practical Application of Heat Sterilization for All Parts of Milking Machines. George H. Hart and William H. Stabler 33
The Development of Acidity in Milk. Dan W. Steuart 52
Proceedings of American Dairy Science Association—1919 61

MARCH. No. 2

Mottles in Butter—Their Causes and Prevention. O. F. Hunziker and D. Fay Hosman 77
Suggestions Regarding the Control of Municipal Milk Supplies. H. A. Harding and M. J. Prucha 107
The Cause and Control of "Buttons" in Sweetened Condensed Milk. L. A. Rogers, A. O. Dahlberg and Alice C. Evans 122
Correction for Volume of Precipitate in the Polarimetric Determination of Lactose in Milk. A. E. Perkins 134
Orla-Jensen's Classification of Lactic Acid Bacteria. P. G. Heineman 143
The Keeping Quality of Milk as Judged by the Colorimetric Hydrogen Ion Determination. L. H. Cooledge and R. W. Wyant 156

MAY. No. 3

Organization of Investigation in Agriculture. E. W. Allen 169
Milk Prices and Cost of Milk Production. F. A. Pearson 180
A Modification of the Haecker and Savage Feeding Standards for Dairy Cattle. Andrew C. McCandlish 190
Fishy Flavor in Butter. J. T. Cusick 194
The Eleventh Annual Students' National Contest in Judging Dairy Cattle. Helmer Rabild 206
A Preliminary Report on the Study of the Temperature at which Milk of Different per cents of Acidity Will Coagulate. T. J. McInerney 220
A Note on the Acidity of Fresh Milk. T. J. McInerney 227
A Score Card for City Ice Cream Plants. F. W. Fabian 230
Committee Appointments for the American Dairy Science Association for 1920 236
Dairy Notes. J. W. Hendrickson 239

JULY. No. 4

Clarification of Milk. Charles E. Marshall and E. G. Hood 245
The Relation of Age of Dam to Observed Fecundity in Domesticated Animals. I. Multiple Births in Cattle and Sheep. Sarah V. H. Jones and James E. Rouse 260

An Unusual Outbreak of Ropy Milk. B. W. Hammer and W. A. Cordes... 291
A Comparative Study of Corn Silage in Concrete and Stave Silos. R. H. Shaw and R. P. Norton... 300
How Do Bacteria Get Into Milk at the Farm and How May Their Number be Reduced? M. J. Prucha, H. A. Harding, H. M. Weeter and W. H. Chambers... 308

SEPTEMBER. No. 5

The Efficiency of Milk Substitutes in Calf Feeding. Geo. Spitzer and R. H. Carr... 315
The Water Buffalo as a Dairy Animal. C. O. Levine... 340
The Relative Value of the Methylene Blue Reduction Test, the Bromthymol Blue Test, and the Bromcresol Purple Test in Determining the Keeping Quality of Milk. E. G. Hastings and Audrey Davenport... 353
The Digestibility of Sorghum Mill Refuse. Andrew C. McCandlish... 367
The Digestibility of Corn Cannery Refuse. Andrew C. McCandlish... 370
A Bacteriological and Biochemical Study of Experimental Butters. Chas. W. Brown, Lulu M. Smith and G. L. A. Ruehle... 375
An Associative Study of Strept. lacticus and B. subtilis in Milk. Max S. Marshall... 406
The Use of Fermented Milk and Milk Diets in Controlling Intestinal Putrefaction. R. C. Fisher... 414
A Comparison of the Decantation Method with Other Methods for the Determination of Fat in Butter. O. R. Overman and Saichi Okimoto.. 425
Abstracts and Reviews of Dairy Literature. H. A. Harding... 430
Dairy Notes. J. W. Hendrickson... 431

NOVEMBER. No. 6

Proportioning the Ingredients for Ice Cream and other Frozen Products. O. E. Williams... 439
A Study of the Incorporation of Proteins in Creamery Butter. R. W. Wyant 452
Factors Influencing the Viscosity of Sweetened Condensed Milk. L. A. Rogers, E. F. Deysher and F. R. Evans... 468
Bitterness in Evaporated Milk. George Spitzer and W. F. Epple... 486
The Effect of Pasteurization on the Number of Bacteria in Milk When this is Determined by the Direct Microscopic Count. E. G. Hastings and Audrey Davenport... 494
Is Ropy Milk Becoming a More Serious Dairy Trouble. H. A. Harding and M. J. Prucha... 502
A Comparison of the Butterfat Content and the Total Solids Content of Creams of Varying Richness Separated from the Same Sample of Milk. B. A. Stiritz and O. R. Overman... 522
A Study in Bulls. Andrew C. McCandlish... 529
Bacterial Control in Milk Plants. Russell S. Smith... 540
Abstracts and Review of Dairy Literature. H. A. Harding... 555
Dairy Notes. J. W. Hendrickson... 556
Index... 561

CONFORMATION AND ITS RELATION TO MILK PRODUCING CAPACITY IN JERSEY CATTLE[1]

JOHN W. GOWEN

Maine Experiment Station, Orono, Maine

During the years in which observing men have kept cattle for milk production there has grown up the opinion that certain points in the conformation of the cow are directly associated with milk production. Perhaps no clearer statement in exemplification of this view can be made than that given by Mr. R. S. Curtis in his book on Cattle Judging (3):

> When judging direct fitness for the block or for dairy purposes all breeding and ancestral records may be disregarded as all practical evidences of utility and quality are largely visible on the exterior of the animal.

Such opinions supported as they are by much of the literature of dairy cattle breeding and management are of especial interest to the biologist. The above quotation expresses as a conclusion one of the ultimate ends of biological investigation for many years, the resolving of the different life processes into terms of correlation between structure and function. The question arises, does this citation from Mr. Curtis express a truth, is it only measurably true or is it fallacious? Toward the solution of this question it is proposed to subject the scores for the conformation of a group of Jersey cows where the milk production of these cows is also known, to biometrical analysis in order to determine the amount of normal individual variation which exists and the relation this variation has to milk flow.

This study was undertaken because experience has shown that a reasonably accurate knowledge of the normal fluctuating variations of a character which is to be used as the basis of selection

[1] Paper from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 129.

is necessary if such selection is to accomplish the desired results. Previous studies (5, 11) have shown that these considerations have immediate bearing on studies involving milk flow as one of the component elements. Milk production is known to be a highly variable character controlled partly by the cow's own internal mechanism, and partly by environmental influences in its final expression. To arrive at any just conclusions regarding the merits of conformation it is necessary to have some knowledge of the influence of the variations of conformation and of milk flow in relation to each other. Such a point of view is entirely free of any preconceived theory as to what particular position one may hold as to the significance of the amount and kind of the variation.

MATERIAL AND METHODS

The present study is based on the material collected by the American Jersey Cattle Club in its Registry of Merit work compiled by Mr. R. M. Gow[2] (2). Part of this data has been published in volume I of the Registry of Merit. The larger portion has not been published. The published data gives the name and registry number, total score on a scale of 100, the milk production, butter-fat percentage, age, etc., of the animal. These records have been used by the author for a study of the relation of conformations of the cows at different ages, as measured by score, to the milk productions of the same cows.

The unpublished data so far as the author is aware have never been subject to analysis. These data are far superior to the published material in that the scores of the individual parts of the body are given. The score card used in this paper is the one officially adopted by the American Jersey Cattle club in 1903. The parts of the body considered together with the points allowed for a perfect score are reproduced below. The score actually given any part of the body of a cow represents the amount by which that part of the cow approaches the ideal dairy form as conceived of by the scorer.

[2] It is a pleasure to acknowledge the indebtedness of the author to Mr. R. M. Gow, Secretary of the American Jersey Cattle Club in furnishing a set of these score cards for this investigation. We are most grateful for the courtesy and coöperation shown by him and the officials under him.

Points scored by cow:

Name.....H. R. No.....

	COUNTS	
Head, 7—		
A—Medium size, lean; face dished; broad between eyes and narrow row between horns	4	.....
B—Eyes full and placid; horns small to medium, incurving; muzzle broad, with muscular lips; strong under jaw	3	.....
Neck, 5—		
Thin, rather long, with clean throat; thin at withers	5	.....
Body, 33—		
A—Lung capacity, as indicated by depth and breadth through body, just back of fore legs	5	.....
B—Wedge shape, with deep, large paunch, legs proportionate to size and of fine quality	10	.....
C—Back straight to hip-bones	2	.....
D—Rump long to tail-setting and level from hip-bones to rump-bones	8	.....
E—Hip-bones high and wide apart; loins broad, strong	5	.....
F—Thighs flat and well cut out	3	.....
Tail, 2—		
Thin, long, with good switch, not coarse at setting-on	2	.....
Udder, 28—		
A—Large size and not fleshy	6	.....
B—Broad, level or spherical, not deeply cut between teats	4	.....
C—Fore udder full and well rounded, running well forward of front teats	10	.....
D—Rear udder well rounded, and well out and up behind	8	.....
Teats, 8—		
Of good and uniform length and size, regularly and squarely placed	8	.....
Milk Veins, 4—		
Large, tortuous and elastic	4	
Size, 3—		
Mature cows, 800 to 1,000 pounds	3	.....
General Appearance, 10—		
A symmetrical balancing of all the parts, and a proportion of parts to each other, depending on size of animal, with the general appearance of a high-class animal, with capacity for food and productiveness at pail	10	.....
	100	

.....

Scorer.

A little thought will make it clear that these records differ from most scientific data in the following important aspect. Each part of the cow is compared with the ideal in the judge's mind. The number of points allowed, or the degree in which the cow before the judge measures up to his ideal, represents the cow's score. Two variables are thus introduced in the final recorded measure of the cow's conformation, the variation in the ideal type from judge to judge and the variation in the opinion of the judges as to how far a given defect is from the said ideal type. The case is something like that of classifying eye colors in human beings. We know that the ability of the different judges varies and that some may vary so far as to be entirely inaccurate but taking the large total number of observers into consideration the analysis of the data gives a good mean of how the average trained dairyman would classify this group of cattle with regard to conformation. The conclusions derived are therefore unique in giving the value of conformation as a guide to milk production as seen through the eyes of the average trained dairyman rather than those of the genius or of the mediocre man.

The data used for this study were complete for the following items.

a. The judge scored all parts of the cow as indicated in the 1903 score card.

b. All cows scored had Registry of Merit records for a period of 365 days.

c. The cows' ages, milk production, butter-fat per cent and butter-fat were given.

Of the total number of records available 1674 records were found to be complete for the above data.

These records are exceptionally suited to the aims of this investigation. They are as near a random sample of the judgment of what constitutes the type of an ideal dairy cow as it would be likely to obtain. One hundred and forty different men have scored one or more of these animals. Most of these men are well known in the Jersey breed. The cows on which scores are taken are all registry of merit cows. The conclusions drawn from the data will consequently be representative of what constitutes the best of the Jersey breed.

The methods used are those in ordinary biometrical use. Sheppard's correction for the second moment has not been used in any of the calculations. Many of the frequencies are quite irregular due to mental habit of the observers centering observations on even numbers or on the fives. No effort has been made to smooth out these irregularities, each constant being calculated from the raw data as it stands.

To facilitate the analysis of the problem the issues may be restated in somewhat more concrete form.

a. How nearly does the representative cow of the Jersey Registry of Merit approach the ideal dairy form, as a whole and as to the various parts into which the body is divided?

b. What is the variation of these cows with respect to this average type?

c. What relation has this variation to the whole form (total score) to the milk production of the cow?

d. Does the variation of part of the body measure accurately or relatively accurately an increase or decrease in the milk production of that cow?

The data necessary to this analysis are found in the back of this paper. The physical constants of the distributions are given in table 1.

The means in table 1 bear directly on the first object of this investigation. In this group of 1674 Jersey Registry of Merit cows the average score was 89.848 ± 0.073, in other words the average cow of this group differed from the ideal Jersey cow by about 10 points. The amount by which the individual body parts of these average cows differ from the ideal Jersey cow is given in the fourth column. The greatest difference is found in the fore udder. This difference is no doubt due to the lack of size and symmetry of this part of the udder on many cows. The other parts of the average cow which differ most from the ideal form are the shape and size of the barrel and the general appearance (the symmetry and balance of the animal as a whole). The size of the average cow approached most nearly the ideal of any of the divisions used in the consideration of these animals.

TABLE 1

Physical constants for the conformation and milk production of Jersey Registry of merit cows

CHARACTER	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	PERFECT CONFORMATION, —MEAN CONFORMATION	$\frac{\text{PERFECT CONFORMATION} - \text{MEAN CONFORMATION}}{\text{PERFECT CONFORMATION}} \times 100$
Head—Medium size, lean; face dished; broad between eyes and narrow between horns.	3.538±0.006	0.360±0.004	10.17±0.12	0.46	11.6
Head—Eyes full and placid; horns small to medium, incurving; muzzle broad, with muscular lips; strong under jaw.	2.638±0.008	0.458±0.005	17.36±0.20	0.36	12.1
Neck—Thin, rather long, with clean throat; thin at withers.	4.453±0.007	0.441±0.005	9.91±0.12	0.55	10.9
Body—Lung capacity, as indicated by depth and breadth through body, just back of fore legs.	4.644±0.006	0.348±0.004	7.50±0.08	0.36	7.1
Body — Wedge shape, with deep, large paunch, legs proportionate to size and of fine quality.	8.996±0.012	0.711±0.008	7.90±0.09	1.00	10.0
Body—Back straight to hip-bones.	1.764±0.004	0.222±0.003	12.60±0.15	0.24	11.8
Body—Rump long to tail-setting and level from hip-bones to rump-bones.	7.119±0.011	0.664±0.008	9.33±0.11	0.88	11.0
Body — Hip-bones high and wide apart; loins broad, strong.	4.596±0.006	0.380±0.004	8.27±0.09	0.40	8.1
Body—Thighs flat and well cut out.	2.732±0.005	0.272±0.003	9.94±0.12	0.27	8.9

out.	2.732±0.005	0.272±0.003			
Tail—Thin, long, with good switch, not coarse at setting-on.	1.826±0.003	0.200±0.002	10.96±0.13	0.17	8.7
Udder—Large size and not fleshy.	5.307±0.009	0.567±0.007	10.69±0.13	0.69	11.6
Udder—Broad, level or spherical, not deeply cut between teats.	3.447±0.007	0.429±0.005	12.43±0.14	0.55	13.8
Udder—Fore udder full and well rounded, running well forward of front teats.	8.452±0.017	1.011±0.012	11.97±0.14	1.55	15.5
Udder — Rear udder well rounded, and well out and up behind.	7.265±0.010	0.611±0.007	8.41±0.09	0.74	9.2
Teats—Of good and uniform length and size, regularly and squarely placed.	7.130±0.011	0.693±0.008	9.72±0.12	0.87	10.9
Milk Veins—Large, tortuous and elastic.	3.473±0.007	0.425±0.005	12.22±0.14	0.53	13.2
Size—Mature cows, 800 to 1,000 pounds.	2.868±0.003	0.163±0.002	5.68±0.07	0.13	4.4
General appearance—A symmetrical balancing of all the parts, and a proportion of parts to each other, depending on size of animal, with the general appearance of a high-class animal, with capacity for food and productiveness at pail.	9.004±0.013	0.761±0.009	8.45±0.09	1.00	10.0
Total score on conformation	89.848±0.073	4.443±0.052	4.95±0.06	10.15	10.2
Milk production	7802.8±29.9	1812.2±21.2	23.22±0.28		

While the differences of the average Jersey cow from the ideal type are of much significance, they do not tell the whole story. The reason for this is that the points allowed for the different body divisions are not the same but are weighted differently. The question on which we desire information is the relative amount of deviation each given body part has as compared with what the ideal would be. This information may be approached and measured numerically in a number of ways. Perhaps the simplest and most easily understood formula for doing this is given below.

$$K = \frac{P.C. - M.C.}{P.C.} \times 100$$

Where K is a whole number ranging from 0 to 100. This constant measures the relative defect in the conformation of a given body part as compared with another in the average typed Jersey cow. $P.C.$ equals the perfect conformation of the ideal cow and $M.C.$ the mean conformation of the average cow.

Column five of table 1 presents this information for this group of Jersey cows. On the scale of this constant the average cow of the 1674 considered ranges from 4.4 to 15.5 units away from the ideal type in the different divisions into which the body conformation is classified.

The most seriously defective places or those which received most consideration from the judges pertained to the size of udder and its blood supply. Thus the fore udder was the furthest from the ideal type; the udder shape taken as a whole was the next part of the body most off type; the size and character of the milk veins were considered the next furthest off the ideal form. The parts into which conformation was divided which deviated least from the ideal were the size or weight of the cow. If the three main divisions into which the score card is divided are considered it is found that the body regions approach nearest to the ideal type; the head next and the udder is furthest removed from this ideal conformation. If the conformation as a whole is compared with the mammary development as a whole it is found that the body form approaches most nearly the ideal. From these con-

siderations it becomes plain that in the minds of these judges the part of the body requiring greatest development in this ideal milch cow is the mammary system as distinguished from the rest of the body.

The variation of this measure for conformation of a given body division is given by the standard deviation. The largest standard deviation for a given part of the body is that for the fore udder. A fairly close second to this is the variation of the general appearance. The part of the conformation exhibiting the lowest variation is the size of the body.

The characters which the judge compares with his ideal are essentially morphological characters. It is therefore of some interest and significance to consider the variability of these characters abstractly. This may be done by means of the coefficient of variation.

The lowest coefficient of variation is that for the total score, the coefficient of variation in this case being only 4.95 ± 0.06. The coefficients of variation for the individual parts of the conformation range from 5.68 to 17.36 with a mean of 10.19. The least variable part of the conformation was the size of the animal. The most variable was that part of the head included in the eyes, horns and muzzle. Considering the parts of the conformation having no direct relation to the organs of milk secretion the mean coefficient of variation was 9.84. The mean coefficient of variation was 10.91 for those parts of the conformation which dealt directly with the milk secreting function. Those parts of the body relating to the milk secreting function are consequently more variable than those relating to the rest of the body. This conclusion seems quite reasonable when it is remembered that the greater part of the mammary conformation relates to the development of the soft part of the body where as the greater number of the other parts making up the conformation relates to bone.

The variability of the milk production checks well with what has previously been found for a pure bred herd of the breed (6). When the variation of the milk production is compared with that of the parts into which the conformation is divided it is

TABLE 2

Coefficients of variation for characters comparable with those here studied.

CHARACTER	COEFFICIENT OF VARIATION	AUTHORITY
Area of comb (domestic fowl)	39.97	Pearl and Pearl (12)
Weight of spleen (English males)	38.21	Greenwood (8)
Milk production (Jersey Random sample herd)	25.57	Gowen (6)
Milk production (Guernsey Advanced Registry)	24.72	Gowen (6)
Milk production (Holstein-Friesian Advanced Registry)	24.27	Gowen (5)
Milk production (Jersey Registry of Merit)	23.22	
Heart weight (English males)	22.22	Greenwood and Brown (9)
Weight of kidneys (English males)	21.05	Greenwood and Brown (9)
Weight of liver (English males)	20.82	Greenwood and Brown (9)
Body weight (English males)	18.91	Greenwood and Brown (9)
Rev. maximum daily milk yield (for given age)	17.998	Gavin (4)
Head—Eyes full and placid; horns small to medium, incurving; muzzle broad, with muscular lips; strong under jaw	17.36	This paper
Weekly milk yield (Ayrshire cattle)	17.08	Pearl and Miner (11)
Breathing capacity (English males)	16.60	Pearson (13)
Body—Back straight to hip-bones	12.60	This paper
Udder—Broad, level or spherical, not deeply cut between teats	12.43	This paper
Milk Veins—Large, tortuous and elastic	12.22	This paper
Udder — Fore udder full and well rounded, running well forward of front teats	11.97	This paper
Tail—Thin, long, with good switch, not coarse at setting-on	10.96	This paper
Udder—Large size and not fleshy	10.69	This paper
Head—Medium size, lean; face dished; broad between eyes and narrow between horns	10.17	This paper
Body—Thighs flat and well cut out	9.94	This paper
Neck—Thin, rather long, with clean throat, thin at withers	9.91	This paper
Teats—Of good and uniform length and size, regularly and squarely placed	9.72	This paper
Body—Rump long to tail-setting and level from hip-bones to rump-bones	9.33	This paper

TABLE 2—*Continued*

CHARACTER	COEFFICIENT OF VARIATION	AUTHORITY
General Appearance—A symmetrical balancing of all the parts, and a proportion of parts to each other, depending on size of animal, with the general appearance of a high-class animal, with capacity for food and productiveness at pail	8.45	This paper
Udder—Rear udder well rounded, and well out and up behind	8.41	This paper
Body—Hip-bones high and wide apart; loins broad, strong	8.27	This paper
Brain weight (Bavarian males)	8.12	Pearl (10)
Body—Wedge shape, with deep, large paunch, legs proportionate to size and of fine quality	7.90	This paper
Body—Lung capacity, as indicated by depth and breadth through body, just back of fore legs	7.50	This paper
Size—Mature cows, 800 to 1000 pounds	5.68	This paper
Length of forearm (English males)	5.24	Pearson and Lee (14)
Length of femur (French males)	5.05	Pearson (13)
Total score on conformation	4.95	This paper
Stature (English males)	3.99	Pearson and Lee (14)

found that the milk yield variation is about twice as much as the variation of the judges estimate of the variability of the different parts making up conformation.

It is of significance to follow this comparison further. Table 2 gives the coefficients of variation of characters of a similar nature to those of conformation save that the coefficients in this material are measure or weight accurately in English or metric units.

Comparison of the coefficients of variation for milk production of the material used in this paper with that of a random sample Jersey herd and for the other cows in the advanced registries of the other breeds shows that so far as the variation of yield is concerned these data are entirely comparable with those of other dairy cattle in this and other breeds.

Some variation constants for bone growth and size data have been included in this table. It will be noted that the coefficients of variation for bone material are in general lower than are those for the scores on the conformation of the parts which require principally the difference in bone size from animal to animal in the make up of their variation constants. The smaller size of these coefficients of variation where actual bone measurements were used as compared with those judged against the ideal make it seem probable that the variability of the score for these parts is somewhat too large as compared with the actual variability as found on the animal.

Other data on variation included in this table pertains to the variation of the soft organs of the body in various species. These data are very variable ranging in value from 8.12 to 39.97. These constants cover such a range that the comparison of them with the data on the variation of the conformation of the soft part of the cow is of doubtful value. The data of this paper on the soft parts deal chiefly with the mammary system. The variation constants for them seem to fall well within the range of the same kinds of data on other species although in general they are grouped near the lower end of this range.

THE CORRELATION OR INTERRELATION OF THE CONFORMATION OF THE BODY PARTS WITH THE VARIATION OF THE MILK SECRETION

This phase of the subject is perhaps the most interesting since it measures and gives the first reliable means of distinguishing between the value of the different points on conformation as they are indicative of the cow's milking capacity. Table 3 gives this information in terms of correlation. The arrangement of the material is according to the amount of correlation which exists between milk production and the conformation of the given part.

The arrangement of this table shows clearly the items covered under conformation which have value in determining what the future milk production of the cow will be. Only one part of the

TABLE 3

Correlation between conformation and milk yield

CHARACTER CORRELATED	CORRELATION COEFFICIENT	CORRELATION COEFFICIENT P. E. r
Milk yield and total score	0.1941±0.0160	12.13
Milk yield and milk veins—Large, tortuous and elastic	0.1908±0.0160	11.93
Milk yield and udder—Large size and not fleshy	0.1906±0.0160	11.91
Milk yield and udder—Rear udder well rounded, and well out and up behind	0.1710±0.0161	10.62
Milk yield and body-wedge shape, with deep, large paunch, legs proportionate to size and of fine quality	0.1657±0.0161	10.29
Milk yield and general appearance—Symmetrical balancing of all the parts, and a proportion of parts to each other, depending on size of animal, with the general appearance of a high-class animal, with capacity for food and productiveness at pail	0.1147±0.0164	6.99
Milk yield and body-thighs flat and well cut out	0.0885±0.0164	5.40
Milk yield and body—Rump long to tail-setting and level from hip-bones to rump-bones	0.0862±0.0165	5.22
Milk yield and udder—Fore udder full and well rounded running well forward of front teats	0.0777±0.0165	4.71
Milk yield and teats—Of good and uniform length and size, regularly and squarely placed	0.0671±0.0165	4.07
Milk yield and head—Medium size, lean; face dished; broad between eyes and narrow between horns	0.0671±0.0165	4.07
Milk yield and tail—Thin, long, with good switch, not coarse at setting-on	0.0634±0.0165	3.84
Milk yield and udder—Broad, level or spherical, not deeply cut between teats	0.0615±0.0165	3.73
Milk yield and size—Mature cows, 800 to 1,000 pounds	0.0611±0.0165	3.70
Milk yield and body—Hip-bones high and wide apart; loins broad, strong	0.0589±0.0165	3.57
Milk yield and neck—Thin, rather long, with clean throat; thin at withers	0.0499±0.0165	3.02

TABLE 3—*Continued*

CHARACTER CORRELATED	CORRELATION COEFFICIENT	CORRELATION COEFFICIENT / P. E. r
Milk yield and head—Eyes full and placid; horns small to medium, incurving; muzzle broad, with muscular lips; strong under jaw	0.0419±0.0165	2.54
Milk yield and body—Lung capacity, as indicated by depth and breadth through body, just back of fore legs	0.0222±0.0166	1.34
Milk yield and body—Back straight to hip-bones	−0.0697±0.0165	4.22

conformation has a minus value when correlated with the milk production of the cows. Put in words this means that as judged by these men the cow which had the *backs straight to hip bones* were very slightly poorer milk producers than those which were not so straight.

All correlation coefficients but two were more than three times the probable error of said coefficient. There are then 15 parts contributing toward the ideal conformation which are indicative of the high milk producers. The total score most nearly represented the milk producing capacities of the cow.

Of the separate divisions into which conformation is divided the *milk veins—large tortuous, and elastic* distinguish the high producer from the low producer most accurately. This conclusion finds interesting conformation in the work of Aldrich and Dana (1). This work dealt with nearly 600 cows. Among the items considered in relation to milk flow were (a) size of wells, (b) diameter of milk veins, (c) length of milk veins.

The correlation coefficients on these data where accurate measurements in English units were used, were (a) Aldrich 0.151 ± 0.031, Dana 0.262 ± 0.027; (b) Aldrich 0.193 ± 0.036, Dana 0.282 ± 0.027; (c) Aldrich 0.003 ± 0.066, Dana 0.211 ± 0.042. These correlations where actual measurements are used are quite close to the results obtained from the data of this paper. The conclusion seems justified therefore that the condition of the milk vein is to some extent an indicator of milk yield.

It may be well to mention an experiment performed by Graves of the Oregon Experiment Station (7), which might to some be considered a contradiction to this conclusion. In this experiment the Station veterinarian ligated the milk veins on an Ayrshire and on a Holstein-Friesian cow. No appreciable diminution of milk flow occurred in either of these cows after the operation was performed and the shock of the operation was over. Graves points out that there are two sets of veins carrying the blood from the udder, the so-called anterior and posterior mammary veins. In ligation only the anterior set are tied off. He says,

> This experiment proves that the posterior mammary veins are capable of carrying all the blood away from the udder. It suggests to us that some cows may have the posterior vessels exceptionally well developed and the exterior mammary or milk veins poorly developed, and yet as much blood may be carried to the udder with the materials for the manufacture of milk as in the cow with the network of milk veins on her body.

It seems entirely likely that this experiment explains why the correlation coefficients between the milk veins and milk production is relatively low. The experiment does not prove that the anterior milk veins are not a fairly good indicator of the cow's milking capacity for it is entirely probable that while under stress the posterior veins can take care of all the blood going to the udder still under normal conditions it is equally probable that the size of these veins is proportional to the amount of blood that is necessary for the veins to carry. The relatively elastic nature of veins and the ease of their regeneration lend further strength to this view. The conclusion previously drawn from the data of this paper are, consequently, sound in showing that the condition of the milk veins is an indicator of the milking possibilities of the cow.

Close seconds to the condition of the milk veins as an indicator of the cow's possible milk yield are the size and character of the udder and the shape of the rear udder. The body size and shape together with the general appearance of the cow are next most indicative of her milk yield. It is interesting to note that the

size of the udder plays a much more important part in the yield than does the shape and contour of the udder. Likewise it seems that the appearance of the udder is more important than is the general form of the body taken as a whole. These facts substantiate the view that a cow with a large capacious barrel and large, elastic udder is likely to be a good milker.

These correlation coefficients are on the whole quite low. In this connection it is of interest to compare the relative value of correlation coefficients with those for actual milk yields over short periods. The problem may be stated thus.

a. What is the relation between the milk production of a short period (say seven days) in a lactation and that for the whole lactation?

b. What is the relation between the milk production of a short period and the milk production of a subsequent whole lactation of which the short period is not a part?

In answering this question the author quotes from some unpublished data soon to be put in bulletin form. Figure 1 shows the results of this comparison.

This figure shows clearly the much superior merit of a milk record even though it be for only seven days as compared with conformation in distinguishing the superior from the inferior dairy cow. The correlation coefficients are arranged in order of their value. This arrangement so far as the items of conformation are concerned is the same as that of table 3. The range in values of the correlation coefficients for milk yield of the seven day test with the milk yield of the year test in another lactation is + 0.8470 to 0.3351. For the seven day test with the year test of the same lactation the range is + 0.8360 to − 0.1157. For the parts considered in determining the conformation the range is + 0.1941 to − 0.0697.

The average correlation coefficient for the seven day test of Holstein-Friesian cattle and the 365 day test of which the seven day test is a part is + 0.570. The average correlation coefficient for the seven day test and 365 day test of which the seven day test is not a part is + 0.550. In other words a seven day test is a much better measure of a cow's ability at the pail than is

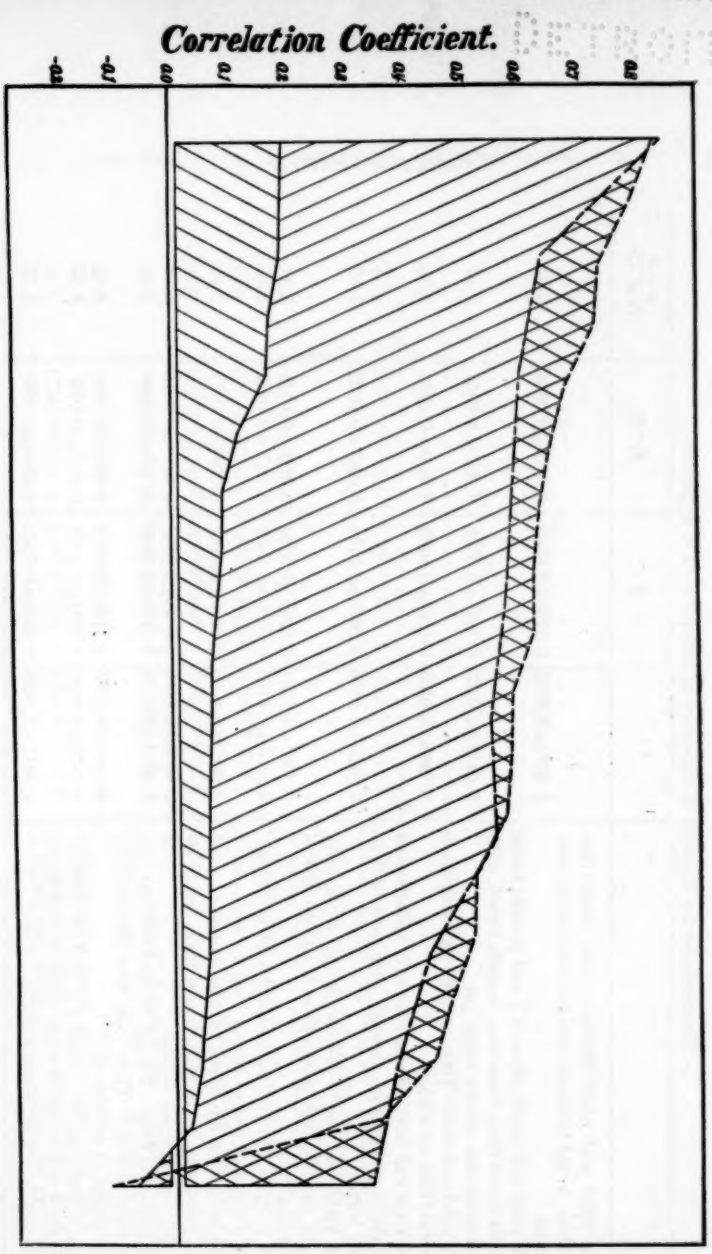

FIG. 1. COMPARATIVE VALUES OF THE CORRELATION COEFFICIENTS

Between (a) conformation and year milk production, (b) seven day test and year milk production where the seven day milk production is a component of the year milk production; and (c) seven day test and year milk production in which the seven day milk yield is in another lactation than the year lactation. The lines designating these relations are (a) ———, (b) - - - - - - - -, (c) — - — - —.

TABLE 4

Constants for the linearity of regression of tables 5 to 23 of appendix

	r	η	$\eta^2 - r^2$	$\frac{\eta^2 - r^2}{P.e\ \eta^2 - r^2}$
Milk yield and head—Medium size, lean; face dished; broad between eyes and narrow between horns.	0.0671±0.0165	0.1268±0.0163	0.0116±0.0035	3.31
Milk yield and head—Eyes full and placid; horns small to medium, incurving; muzzle broad, with muscular lips, strong under jaw.	0.0419±0.0165	0.1048±0.0163	0.0092±0.0031	2.97
Milk yield and neck—Thin, rather long, with clean throat; thin at withers.	0.0499±0.0165	0.1120±0.0163	0.0101±0.0032	3.16
Milk yield and body—Lung capacity, as indicated by depth and breadth through body, just back of fore legs.	0.0222±0.0166	0.0678±0.0164	0.0041±0.0022	1.86
Milk yield and body—Wedge shape, with deep, large paunch, legs proportionate to size and of fine quality.	0.1657±0.0161	0.1959±0.0160	0.0109±0.0035	3.11
Milk yield and body—Back straight to hip-bones.	−0.0697±0.0165	0.0926±0.0162	0.0037±0.0020	1.85
Milk yield and body—Rump long to tail-setting and level from hip-bones to rump-bones.	0.0862±0.0165	0.1091±0.0162	0.0045±0.0022	2.05
Milk yield and body—Hip-bones high and wide apart; loins broad, strong.	0.0589±0.0165	0.0733±0.0163	0.0019±0.0015	1.27
Milk yield and body—Thighs flat and well cut out.	0.0885±0.0164	0.1173±0.0162	0.0059±0.0026	2.27
Milk yield and tail—Thin, long, with good switch, not coarse at setting-on.	0.0634±0.0165	0.1128±0.0162	0.0087±0.0031	2.81
Milk yield and udder—Large size and not fleshy.	0.1906±0.0160	0.2281±0.0156	0.0157±0.0041	3.83
Milk yield and udder—Broad, level or spherical, not deeply cut between teats.	0.0615±0.0165	0.0983±0.0162	0.0059±0.0026	2.27

Milk yield and udder—Fore udder full and well rounded, running well forward of front teats.	0.0777±0.0165	0.1316±0.0162	0.0113±0.0035	3.23
Milk yield and udder—Rear udder well rounded, and well out and up behind.	0.1710±0.0161	0.2272±0.0156	0.0224±0.0049	4.57
Milk yield and teats—Of good and uniform length and size, regularly and squarely placed.	0.0671±0.0165	0.1264±0.0163	0.0115±0.0035	3.29
Milk yield and milk veins—Large, tortuous and elastic.	0.1908±0.0160	0.2089±0.0156	0.0072±0.0028	2.57
Milk yield and size—Mature cows, 800 to 1,000 pounds.	0.0611±0.0165	0.0910±0.0162	0.0045±0.0022	2.05
Milk yield and general appearance—A symmetrical balancing of all the parts, and a proportion of parts to each other, depending on size of animal, with the general appearance of a high-class animal, with capacity for food and productiveness at pail.	0.1147±0.0164	0.1534±0.0161	0.0104±0.0034	3.06
Total score	0.1941±0.0160	0.2198±0.0156	0.0106±0.0034	3.12

the total score or any part of the cow's conformation as judged by the average trained dairyman. This general relation between the milk yields of the various length of periods has been found to hold for the other breeds (6).

Before gathering together the conclusions it may be well to present the evidence to show that the regressions on which these correlation coefficients are based are all linear. The linearity of this regression is determined by the relation of the correlation coefficient and the correlation ratio. This relation is given in table 4.

Table 4 shows the correlation ratio for the conformation of each part of the body when correlated with milk yield to be approximately equal to the correlation coefficient for the same variables. The difference between the correlation ratio squared and the correlation coefficient squared is slight. The highest of these differences is only 0.0224 ± 0.0049. This difference deals with the regressions of the conformation of the rear udder on milk yield. When the differences of the correlation ratio squared minus the correlation coefficient squared are compared with their probable errors as is done in the last column of this table it is found that out of the nineteen differences only nine are more than three times their probable errors. Besides this the highest difference is only 4.57 times its probable error. It is doubtful indeed if nineteen correlation tables could be selected at random from material known to be linear in its regression and have the result conform more nearly than the tables of this paper.

The results of this analysis on which the conclusions are based are consequently free from any bias due to the type of regression lines not being linear.

SUMMARY

This paper presents a biometrical analysis of the relation of conformation to the milk producing capacity of the Jersey cow. Exceptional data have been made available to this Station for the solution of this problem by the courtesy of Mr. R. M. Gow. These data give the exact scores of 1674 registry of merit Jersey cows as determined by about 140 judges.

The mean conformation as measured by score is given for the cow as a whole and for the parts into which it is divided. Within this group of Jersey cows the average score was 89.848 ± 0.073. The average Jersey cow was therefore about 10 points below the ideal Jersey cow. When this measure of the conformation as a whole is analyzed in terms of its parts, it was found that the fore udder differed most from the ideal type.

When considered in abstract terms it was found that the most seriously defective parts of the body in the minds of the judges had to deal with the mammary system, its size and blood supply. Of those parts which dealt with the body proper the least ideal was the barrel.

The variation of the different body parts is compared by means of the standard deviation and the coefficient of variation. The most variable part of the body included the eyes, horns, and muzzle, the least variable the size of the body.

The variability is further compared with characters of similar nature to those of conformation save that the variability was determined on data measured or weighed accurately in English or metric units. Bone material was in general found to vary less than the scores assigned to parts of the body depending chiefly on variations in bone length. The amount of this difference was slight, however. The variation of the udder parts was found to be at the lower end of the range of variation of other soft parts of the body.

Correlation coefficients for milk yield with the conformation as a whole and for the various parts were determined. The correlation coefficients ranged from − 0.0697 ± 0.0165 to 0.1941 ± 0.0160. Out of the nineteen correlations only one was minus in value; seventeen were more than three times their probable error. The total score had the highest correlation with milk yield. The parts of the conformation having a distinctly significant relation to milk production of the cow were the milk veins, size and condition of udder, the size and shape of rear udder, the shape and size of barrel and the general appearance of the cow.

The relative merits of conformation as a guide to the milk producing capacity of a cow and a short time milk record are

considered. The results show that a seven day test has a correlation coefficient with the year milk yield of the cow of approximately 2½ times that of the conformation or any part of the conformation. The short test consequently is superior to the conformation as a guide to milk production.

Constants for the regression of each correlation table are calculated and the regression shown to be linear.

The raw data are given in appendix tables 5 to 23.

TABLE 5

Correlation surface for variables milk yield (365 days) and the conformation of the cow taken as a whole

MILK	WHOLE CONFORMATION															TOTAL
	98–100	96	94	92	90	88	86	84	82	80	78	76	74	72	70–72	
pounds																
17,900–16,900					1											1
16,900				1												1
15,900																
14,900			6	2	2		2		1							13
13,900			2	1	2	1	1									7
12,900	1	1	5	6	3		2		1							19
11,900	1	4	7	15	13	5		2		1						48
10,900		9	23	15	19	12	5	4	2		1					90
9,900	5	9	27	35	38	35	22	8	4	9	4					196
8,900	3	16	45	57	48	39	25	21	10	7	6	1	1	1		280
7,900	1	13	45	63	82	73	48	37	20	14	4	7	2			409
6,900		8	25	60	76	78	44	30	22	22	6	3		1	1	376
5,900	1	3	21	30	39	37	37	13	6	12	4		1		1	205
4,900		3		9	6	2	2	1	4	1						28
3,900–2,900								1								1
Total.....	12	66	206	294	329	282	188	117	70	66	25	11	4	2	2	1674

TABLE 6

Correlation surface for variables milk yield (365 days) and the conformation of head, medium size, lean; face dished; broad between eyes and narrow between horns

MILK	HEAD															TOTAL
	3.8–4.0	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8–1.0	
pounds																	
17,900–16,900	1																1
16,900			1														1
15,900																	
14,900	4	4	3		1	1											13
13,900	5	1	1														7
12,900	1	6	9	3													19
11,900	23	4	15	3	3												48
10,900	34	18	19	6	3	8		2									90
9,900	63	33	43	20	5	25	2	2	1		1					1	196
8,900	98	50	81	10	5	31	1	2			2						280
7,900	113	72	118	25	14	60	2	5									409
6,900	90	70	129	19	11	50	2	2			3						376
5,900	46	51	74	12	4	15		2	1								205
4,900	7	3	10	1		6					1						28
3,900–2,900					1												1
Total.....	485	312	503	99	47	196	7	15	2		7					1	1674

TABLE 7

Correlation surface for variables milk yield (365 days) and the conformation of head, eyes full and placid; horns small to medium, incurving; muzzle broad, with muscular lips; strong under jaw

MILK	HEAD											TOTAL
	2.8–3.0	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8–1.0	
pounds												
17,900–16,900	1											1
16,900		1										1
15,900												
14,900	6	3	2	1		1						13
13,900	2	2	3									7
12,900	8	10	1									19
11,900	22	8	13		1	4						48
10,900	34	34	16	2		3		1				90
9,900	88	42	40	13		11		1			1	196
8,900	116	73	58	15		12	3	3				280
7,900	143	101	99	20	1	42	1				2	409
6,900	119	95	99	31		31	1					376
5,900	78	46	54	15	2	8		2				205
4,900	11	7	8	1		1						28
3,900–2,900	1											1
Total.....	629	422	393	98	4	113	5	7			3	1674

TABLE 8

Correlation surface for variables milk yield (365 days) and the conformation of neck, thin, rather long, with clean throat; thin at withers

MILK	NECK																TOTAL
	4.8–5.0	4.6	4.4	4.2	4.0	3.8	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.2	2.0	1.8–2.0	
pounds																	
17,900–16,900	1																1
16,900	1																1
15,900																	
14,900	6	2	4			1											13
13,900	3	2	1	1													7
12,900	5	3	5	4		1		1									19
11,900	14	7	10	3		11					3						48
10,900	23	18	23	6		15	1	2			2						90
9,900	59	25	55	12	3	32	4	4			1		1				196
8,900	83	45	75	23	7	33	1	9			2		1			1	280
7,900	102	70	116	20	5	66	12	10	1		6		1				409
6,900	81	60	104	25	9	64	6	19	1		6	1					376
5,900	49	29	78	13		26	2	6			1	1					205
4,900	6	1	13	2	1	4	1										28
3,900–2,900						1											1
Total.....	433	262	484	109	25	254	27	51	2		21	2	3			1	1674

TABLE 9

Correlation surface for variables milk yield (365 days) and the conformation of body, lung capacity, as indicated by depth and breadth through body, just back of fore legs

MILK	BODY													TOTAL
	4.8–5.0	4.6	4.4	4.2	4.0	3.8	3.6	3.4	3.2	3.0	2.8	2.6	2.4–2.6	
pounds														
17,900–16,900	1													1
16,900			1											1
15,900														
14,900	5	5	3											13
13,900	5	1	1											7
12,900	7	6	4		2									19
11,900	28	6	12			1		1						48
10,900	47	13	16	3		7	2	1			1			90
9,900	102	20	40	12	3	17		2						196
8,900	133	34	66	14	1	24	4	3			1			280
7,900	217	37	89	24	1	35	4	1			1			409
6,900	172	52	84	20	2	36	4	2			3		1	376
5,900	111	27	39	15	2	7	2	1			1			205
4,900	13	2	11			2								28
3,900–2,900	1													1
Total.....	842	203	366	88	11	129	16	11			7		1	1674

TABLE 10

Correlation surface for variables milk yield (365 days) and the conformation of body, wedge shape, with deep, large pauch, legs proportionate to size and of fine quality

MILK	BODY														TOTAL
	9.7–10.0	9.4	9.1	8.8	8.5	8.2	7.9	7.6	7.3	7.0	6.7	6.4	6.1	5.8–6.1	
pounds															
17,900–16,900	1														1
16,900				1											1
15,900															
14,900	5	2	1	4				1							13
13,900	1	4		1			1								7
12,900	4	3	5	5		1	1								19
11,900	22	5	3	12		4	2								48
10,900	25	23	4	20	1	7	8		2						90
9,900	54	28	9	53	4	16	24	1	2		4	1			196
8,900	76	50	8	66	5	32	32	3	3		4	1			280
7,900	94	45	18	117	12	54	51	5	8	1	3			1	409
6,900	74	53	21	95	11	57	48		11		6				376
5,900	25	19	5	78	7	29	36	1	1		4				205
4,900	4	4	1	6		7	4			1	1				28
3,900–2,900				1											1
Total.....	385	236	75	459	40	207	207	11	27	2	22	2		1	1674

TABLE 11

Correlation surface for variables milk yield (365 days) and the conformation of body, back straight to hip-bones

MILK	BODY										TOTAL
	1.8–2.0	1.6	1.4	1.2	1.0	0.8	0.6	0.4	0.2	0.0–2	
pounds											
17,900–16,900	1										1
16,900		1									1
15,900											
14,900	8	3	1			1					13
13,900	5	1	1								7
12,900	9	4	5	1							19
11,900	28	10	8	1		1					48
10,900	48	23	17	1				1			90
9,900	112	38	36	2	1	7					196
8,900	166	49	40	9		15				1	280
7,900	261	75	59	2		12					409
6,900	242	75	50	1	2	6					376
5,900	128	43	28	1	1	4					205
4,900	24	3	1								28
3,900–2,900			1								1
Total.....	1032	325	247	18	4	46		1		1	1674

TABLE 12

Correlation surface for variables milk yield (365 days) and the conformation of body, rump long to tail-setting and level from hip-bones to rump-bones

MILK	BODY														TOTAL
	7.7-8.0	7.4	7.1	6.8	6.5	6.2	5.9	5.6	5.3	5.0	4.7	4.4	4.1	3.8-4.1	
pounds															
17,900–16,900				1											1
16,900					1										1
15,900															
14,900	4	4	4				1								13
13,900	1	3	1	2											7
12,900	3	8	3	1	1		3								19
11,900	9	19	6	8	2	2	2								48
10,900	22	25	11	17	5	6	3				1				90
9,900	49	40	26	30	11	18	17		2		2			1	196
8,900	61	69	30	54	7	25	30	1	2			1			280
7,900	97	87	43	81	14	34	41	1	1	1	9				409
6,900	61	80	54	64	17	42	45		6		7				376
5,900	38	48	28	47	8	13	15		4	1	3				205
4,900	7	6	2	6	2	2	3								28
3,900–2,900				1											1
Total.....	352	389	208	312	68	142	160	2	15	2	22	1		1	1674

TABLE 13

Correlation surface for variables milk yield (365 days) and the conformation of body, hip-bones high and wide apart; loins broad, strong

MILK	BODY															TOTAL
	4.8-5.0	4.6	4.4	4.2	4.0	3.8	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.2	2.0	1.8-2.0	
pounds																	
17,900–16,900						1											1
16,900		1															1
15,900																	
14,900	1	5	5			1	1										13
13,900	5	1	1														7
12,900	8	5	5		1												19
11,900	31	5	11	1													48
10,900	40	12	27	3	1	7											90
9,900	87	28	43	6	4	25		1	1		1						196
8,900	138	33	61	17	1	22	2	4			1					1	280
7,900	165	49	92	25	3	61	2	7			5						409
6,900	178	45	81	19	4	42	4	2			1						376
5,900	82	26	59	7	3	23	1	1			2						205
4,900	8	9	3	1		7											28
3,900–2,900			1														1
Total.....	743	219	389	79	17	189	11	15	1		10					1	1674

TABLE 14

Correlation surface for variables milk yield (365 days) and the conformation of body, thighs flat and well cut out

MILK	BODY											TOTAL
	2.8–3.0	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8–1.0	
pounds												
17,900–16,900	1											1
16,900	1											1
15,900												
14,900	11	2										13
13,900	5	1	1									7
12,900	15	1		3								19
11,900	35	6	4	1		2						48
10,900	59	16	8	2		5						90
9,900	124	33	25	6		8						196
8,900	182	42	36	10		8	1				1	280
7,900	224	76	67	13	3	24	1				1	409
6,900	211	74	55	13	3	14	2	3			1	376
5,900	109	43	31	12		10						205
4,900	17	5	3	2		1						28
3,900–2,900		1										1
Total.....	994	300	230	62	6	72	4	3			3	1674

TABLE 15

Correlation surface for variables milk yield (365 days) and the conformation of tail, thin, long, with good switch, not coarse at setting-on

MILK	TAIL										TOTAL
	1.9–2.0	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.0	
pounds											
17,900–16,900	1										1
16,900		1									1
15,900											
14,900	10		2		1						13
13,900	7										7
12,900	8	3	2		3	3					19
11,900	30	10	4		1	2				1	48
10,900	64	5	8			11				2	90
9,900	121	15	30	1	3	17		3		6	196
8,900	180	22	42	6	5	16	2	2		5	280
7,900	255	22	74	4	6	41	1	1		5	409
6,900	202	30	74	8	9	38		4		11	376
5,900	109	13	44	4	8	20		4		3	205
4,900	15	6	5			2					28
3,900–2,900	1										1
Total.....	1003	127	285	23	36	150	3	14		33	1674

TABLE 16

Correlation surface for variables milk yield (365 days) and the conformation of udder, large size and not fleshy

MILK	UDDER																TOTAL
	5.8–6.0	5.6	5.4	5.2	5.0	4.8	4.6	4.4	4.2	4.0	3.8	3.6	3.4	3.2	3.0	2.8–3.0	
pounds																	
17,900–16,900																	1
16,900		1															1
15,900																	
14,900	4	1	2	2	1	1	1				1						13
13,900	2	1	2	2													7
12,900	10	2	1	1		2	2				1						19
11,900	22	4	7	3		8	2		1		1						48
10,900	40	10	11	10	5	7	2	2	2		1						90
9,900	73	17	30	20	6	28	7	8			5		2				196
8,900	103	39	37	23	4	44	7	10	2	1	6		3			1	280
7,900	117	40	59	28	15	83	26	18	2	1	15	1	2			2	409
6,900	73	26	67	34	18	77	27	24	5	4	21						376
5,900	33	12	33	21	9	48	16	18	2	4	9						205
4,900	4	3	4	3	1	7	1	3			2						28
3,900–2,900						1											1
Total.....	481	156	253	147	59	306	91	84	14	10	62	1	7			3	1674

TABLE 17

Correlation surface for variables milk yield (365 days) and the conformation of udder, b road, level or spherical, not deeply cut between teats

MILK	UDDER																TOTAL
	3.8–4.0	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8–1.0	
pounds																	
17,900–16,900						1											1
16,900		1															1
15,900																	
14,900	4	2	3	1		2					1						13
13,900	1	1	3			1	1										7
12,900	5	5	5	1		3											19
11,900	17	8	8	3	1	10		1									48
10,900	32	10	26	7	3	9		2	1								90
9,900	62	25	55	9	6	30	6				2					1	196
8,900	79	42	74	16	7	39	8	7	5		3						280
7,900	112	45	109	27	25	75	7	5			4						409
6,900	81	52	109	29	15	69	7	6			8						376
5,900	53	22	58	15	11	35	2	6	2		1						205
4,900	7	4	6	2	2	6	1										28
3,900–2,900					1												1
Total.....	453	217	456	110	71	280	32	27	8		19					1	1674

TABLE 18

Correlation surface for variables milk yield (365 days) and the conformation of udder, fore udder full and well rounded, running well forward of front teats

MILK	UDDER															TOTAL
	9.5–10.0	9.0	8.5	8.0	7.5	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5	3.0	2.5–3.0	
pounds																
17,900–16,900			1													1
16,900	1															1
15,900																
14,900	3	4	2		3		1									13
13,900	2	1	2		1		1									7
12,900	1	8	5	2	1		2									19
11,900	12	8	15	2	6	1	3		1							48
10,900	18	17	19	16	14	2	4									90
9,900	29	31	47	22	47	9	5	3	3							196
8,900	48	43	83	23	44	12	15	3	7	1	1					280
7,900	62	57	102	52	68	17	31	7	4		7	2				409
6,900	54	43	105	51	69	20	19	5	5		3		1		1	376
5,900	33	23	48	41	40	4	8	3	4				1			205
4,900	3	1	13	4	5		1				1					28
3,900–2,900		1														1
Total.....	266	237	442	213	298	65	90	21	24	1	12	2	2		1	1674

TABLE 19

Correlation surface for variables milk yield (365 days) and the conformation of udder, rear udder well rounded, and well out and up behind

MILK	UDDER														TOTAL
	7.7–8.0	7.4	7.1	6.8	6.5	6.2	5.9	5.6	5.3	5.0	4.7	4.4	4.1	3.8–4.1	
pounds															
17,900–16,900	1														1
16,900	1														1
15,900															
14,900	7			4	1						1				13
13,900	3	2			2										7
12,900	11	1	2	1	2	2									19
11,900	18	15	3	9		2	1								48
10,900	49	18	7	8	4	3	1								90
9,900	77	34	25	34	3	11	10				2				196
8,900	111	59	33	41	4	19	11		2						280
7,900	131	80	43	84	9	30	25	1	3		1			2	409
6,900	94	58	55	84	15	37	27	1	3		2				376
5,900	42	42	20	50	10	26	11				2	1		1	205
4,900	8	6	4	4	2	2	2								28
3,900–2,900				1											1
Total.....	553	315	192	320	52	132	88	2	8		8	1		3	1674

TABLE 20

Correlation surface for variables milk yield (365 days) and the conformation of teats, of good and uniform length and size, regularly and squarely placed

MILK	TEATS												TOTAL
	7.5–8.0	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5	3.0	2.5	2.0–2.5	
pounds													
17,900–16,900					1								1
16,900			1										1
15,900													
14,900	5	2	4				2						13
13,900	2	2	2						1				7
12,900	11	4	4										19
11,900	21	12	7	4	4								48
10,900	44	23	18	1	3		1						90
9,900	85	51	37	11	8	3	1						196
8,900	133	64	54	13	10	3	1		2				280
7,900	146	91	102	32	31	1	3		3				409
6,900	127	98	87	29	28	3	1		2			1	376
5,900	68	62	38	19	15	1	2						205
4,900	7	11	7	1	2								28
3,900–2,900		1											1
Total.....	649	421	361	110	102	11	11		8			1	1674

TABLE 21

Correlation surface for variables milk yield (365 days) and the conformation of milk veins, large, tortuous and elastic

MILK	MILK VEINS											TOTAL
	3.8–4.0	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.2	2.0	1.8–2.0	
pounds												
17,900–16,900						1						1
16,900		1										1
15,900												
14,900	7	2	1	3								13
13,900	1		3	2		1						7
12,900	10	3	4		2							19
11,900	24	5	9	4	2	2	1				1	48
10,900	41	13	23	2	1	9	1					90
9,900	80	22	47	13	7	26		1				196
8,900	104	29	66	18	20	32	5	1	1		4	280
7,900	148	33	97	28	24	63	3	10	1		2	409
6,900	85	31	79	53	30	67	13	6	5		7	376
5,900	52	17	52	21	17	28	11	2	1		4	205
4,900	5		12	3	4	3		1				28
3,900–2,900							1					1
Total.....	557	156	393	147	107	232	35	21	8		18	1674

TABLE 22

Correlation surface for variables milk yield (365 days) and the conformation of size, mature cows, 800 to 1,000 pounds

MILK	SIZE															TOTAL
	2.8-3.0	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4	0.2	0.0-.2	
pounds																
17,900–16,900	1															1
16,900	1															1
15,900																
14,900	13															13
13,900	7															7
12,900	19															19
11,900	46	1	1													48
10,900	84	3	1			2										90
9,900	191	3	2													196
8,900	264	7	4	2		2									1	280
7,900	379	13	6	4		6			1							409
6,900	349	11	8	1	1	3	2				1					376
5,900	185	7	5	5		3										205
4,900	25		2	1												28
3,900–2,900	1															1
Total.....	1565	45	29	13	1	16	2		1		1				1	1674

TABLE 23

Correlation surface for variables milk yield (365 days) and the conformation of general appearance,—a symmetrical balancing of all the parts, and a proportion of parts to each other, depending on size of animal, with the general appearance of a high class animal, with capacity for food and productiveness at pail

MILK	GENERAL APPEARANCE																	TOTAL
	9.7-10.0	9.4	9.1	8.8	8.5	8.2	7.9	7.6	7.3	7.0	6.7	6.4	6.1	5.8	5.5	5.2	4.9-5.2	
pounds																		
17,900–16,900	1																	1
16,900				1														1
15,900																		
14,900	5	6	1	1														13
13,900	1	1		4			1											7
12,900	3	8		2		3	2				1							19
11,900	21	11	3	8			4				1							48
10,900	26	14	6	32		6	2		2		1	1						90
9,900	55	31	6	55	5	16	18		6		3						1	196
8,900	75	44	9	63	10	34	28	4	3		4	1		3			2	280
7,900	93	58	20	109	14	36	61	2	6		6	2		2				409
6,900	67	51	15	121	10	47	49	1	9		5						1	376
5,900	41	35	6	61	3	29	20	1	2	1	6							205
4,900	7	4	1	3	1	8	3		1									28
3,900–2,900											1							1
Total.....	395	263	67	460	43	179	188	8	29	1	28	4		5			4	1674

REFERENCES

(1) Aldrich, A. M., and Dana, J. W. 1917 The relation of the milk veins system to production. In Bul. 202, Vermont Agricultural Experiment Station, p. 1–24, fig. 3.

(2) American Jersey Cattle Club. 1911 Register of Merit of Jersey Cattle, vol. i to iv.

(3) Curtis, Robert S. 1915 The fundamentals of live stock judging and selection. New York, p. 450, fig. 180.

(4) Gavin, W. F. 1913 The interpretation of milk records. In Jour. Roy. Agric. Soc., lxxiii, p. 1–22.

(5) Gowen, John W. 1919 Variations and mode of secretion of milk solids. In Jour. of Agri. Research, xvi, no. 3, p. 79–102.

(6) Gowen, John W. Studies in milk secretion. V. On the variations and correlations of milk secretion with age. To appear in Genetics.

Gowen, John W. VI. On the variations and correlations of butter-fat percentage with age in Jersey cattle. To appear in Genetics.

(7) Graves, R. R. 1916 An experiment with milk veins. In Hoard's Dairyman, iii, no. 2, p. 687 and 717, fig. 6.

(8) Greenwood, M. 1904 A first study of the weight, variability, and correlation of the human viscera, with special reference to the healthy and diseased heart. In Biometrika, iii, p. 63–84.

(9) Greenwood, M., and Brown, T. W. 1913 A second study of the weight, variability and correlation of human viscera. In Biometrika, ix, p. 473–485.

(10) Pearl, Raymond 1905 Biometrical studies on man. I. Variations and correlations in brain weight. In Biometrika, iv, p. 13–104.

(11) Pearl, Raymond, and Miner, John R. 1919 The variation of the milk of Ayrshire cows in quantity and fat content of their milk. In Ann. Rept. Maine Agricultural Experiment Station, 1919, p. 57–64.

(12) Pearl, Raymond, and Pearl, Maud DeWitt 1909 Data on variation in the comb of the domestic fowl. In Biometrika, vi, p. 420–432.

(13) Pearson, Karl 1899 Mathematical contributions to the theory of evolution. V. On the reconstruction of the stature of prehistoric races. In Phil. Trans, R. Soc. London, vol. 192A, p. 162–244, 2 pl.

(14) Pearson, Karl and Lee, Alice. 1897 Mathematical contributions to the theory of evolution. On the relative variation and correlation in civilized and uncivilized races. In Proc. R. Soc. London, vol. lxi, no. 375, p. 343–357.

EXPERIMENTS WITH AND PRACTICAL APPLICATION OF HEAT STERILIZATION FOR ALL PARTS OF MILKING MACHINES

GEORGE H. HART AND WILLIAM H. STABLER

Department of Veterinary Science, University of California, Berkeley, California

INTRODUCTION

The last twenty-five years have seen marked improvements in the construction of milking machines. Today a number of makes have been sufficiently perfected and are milking cows so successfully that they may be considered a practical success from the mechanical standpoint.

Labor difficulties due to the war gave a great impetus to the installation of milking machines. Today the capital invested in the manufacturing plants as well as in machines distributed on dairy farms is so large that investigation into the difficulties encountered in their operation is greatly needed.

A review of the literature of this country and abroad on such investigations shows it to be quite extensive. A great many experiments have been initiated to ascertain the mechanical difficulties and the relative production that can be secured with their use as compared with hand milking. With these factors we were not concerned but have devoted our attention to ascertaining the best method of eliminating excessive numbers of bacteria in machine drawn milk.

The sanitary side of milking machine operation was investigated early in their development, at which time not nearly so much was known about the origin of the bacterial flora in milk as at present. Consequently it must be recognized that some of the early bacteriological work on this subject is no longer of any value in the light of our present day knowledge.

PUBLISHED INVESTIGATIONS ON BACTERIA IN MACHINE DRAWN MILK AND THE USE OF VARIOUS STERILIZING AGENTS

Among the most important works on this subject the following will be mentioned. F. C. Harrison (1) of the Guelph Experiment Station in Canada reported, in 1897, a rather extensive series of bacteriological experiments on milk drawn by hand and by the Thistle machine. He concluded that machine drawn milk contained more bacteria than hand drawn milk under the same conditions. This he attributed to contamination of teat cups with hairs and dirt from the cow, inability of the rubber parts of the machine to stand sterilization by steaming or scalding, and letting the cups fall to the floor in changing from cow to cow.

In 1902, Bordas and Raczkowski (2), in France, demonstrated a higher bacterial content in machine drawn milk even when special antiseptic precautions were taken. Their experiments, however, include only seven bacterial counts in all and therefore are not conclusive.

In 1907, W. A. Stocking (3), reported experiments with various methods of cleaning milking machines. Satisfactory results were obtained by means of heat but even boiling in water for three quarters of an hour did not keep the rubber parts sterile. The bacterial count of the milk produced after this treatment was well below 10,000 per cubic centimeter. Placing the rubber parts, after washing, in brine for several hours reduced the bacterial count of machine drawn milk to about half of that drawn by hand. In this case he scalded the rubber parts just before use after taking them out of the brine solution or just before putting them into the solution. Heat, therefore, was probably the main factor in getting the machines sufficiently clean to produce all of his low count samples.

At the Kansas Station, in 1906, Erf (4) in a general treatise on the construction and evolution of the milking machine reports several tests with antiseptic solutions for sterilizing parts. Formaldehyde, boric acid and lime were tried with the result that while formaldehyde was the most efficient it was not practical

and lime was concluded to be the most satisfactory. After soaking in these solutions the rubber parts were thoroughly rinsed in boiling water before use.

In 1907, Stocking and Mason (5) reported work on this problem in which steam, Gold Dust solution 1–300, lime water, borax 1 pound in 15 quarts of water, 2.5 to 3.5 per cent formalin and 10 per cent brine were used. They were only able to keep the tubes in a satisfactorily sterile condition with steam and formaldehyde. The steam was applied without pressure for one hour and quickly injured the rubber tubing so it could not be used.

Hastings and Hoffman (6), at the Wisconsin Agricultural Experiment Station, in 1906, showed that with lime solution as a disinfectant for rubber parts 150 samples of machine drawn milk gave an average lower count than 137 hand drawn samples. This was done on the station herd where better care was probably taken of the machines than would have occurred under ordinary farm conditions. The lime solution was of a strength equal to a twentieth normal solution of alkali. Care was used to obtain perfectly fresh unslacked lime and to maintain an excess in the vessel.

Elizabeth Meek (7) reported a series of counts with hand drawn and machine drawn milk. At first the machines were merely being rinsed out successively with cold, tepid and hot water when the milk drawn by them was high in bacterial content. Later the machines were steamed and the hose and cups stored in brine solution after being thoroughly washed with a tube brush. After this treatment the bacterial content of the milk produced by them was reduced to approximately that found in the hand milked product.

Brainard (8) in a general bulletin on clean and sanitary milk reports bacterial counts of machine drawn milk. For several days after the machine was installed at the Virginia Experiment Station the count ranged from 32,000 to 35,000. It was then not used for three days and when again placed in operation the count increased to 1,250,000. He then prepared a lime water bath for the rubber parts and in three days the count was down

and thereafter ranged between 34,000 and 100,000, which compared favorably with the hand drawn milk.

Harding, Wilson and Smith (9), in 1909, concluded that the most important item in obtaining quality of product was the immersing of the rubber parts in 10 per cent brine or similar solution between milkings. This, they state, is "many times more efficacious than the most careful steaming." This conclusion has not been borne out under actual field conditions in this state.

Wing (10), in 1913, showed that many colonies would develop on plates made from 15 per cent brine in which rubber tubing from milking machines had been kept. A number of substances were then added to the brine including hydrogen peroxide, alcohol, permanganate of potash, formaldehyde, vinegar, acetic acid, copper sulphate and, finally, chloride of lime. She concluded that brine would not keep parts sterile but that when chloride of lime was added this result was practically obtained. It was necessary, however, to frequently add fresh chloride of lime. With sterile machine parts she was able to produce low count milk.

A recent and extensive experimental work on milking machines as a source of bacteria in milk has been published by Reuhle, Breed and Smith (11). They have carried on elaborate experiments in maintaining milking machines in a bacteria free condition by using antiseptic solutions, some of which are 10–13 per cent brine solution, chloride of lime, the two together, lime water, cold running water and a proprietary germicide, "Montanin." Satisfactory results are claimed for all of these but the conclusion is made that chloride of lime in saturated brine is the most practical and efficient. The work is noticeably lacking in experiments on the value of heat sterilization for rubber parts which is surprising in the light of the finding of Haecker and Little (12), in 1908; Stocking (3), in 1907; Edwards (13), in 1907, and the widespread unsatisfactory results from the bacteriological standpoint with all the chemical preparations when used under ordinary dairy ranch conditions.

LIMITATIONS OF CHEMICAL SOLUTIONS AS STERILIZING AGENTS

An efficient antiseptic bath for milking machine rubber parts must meet certain fundamental requirements. First, it must keep the rubber parts bacteriologically clean; second, it must not deteriorate the rubber rapidly; third, leave no deposit in the teat cups and tubes; fourth, leave no objectionable taste, odor or preservative in the milk; fifth, be fairly stable.

All of the preparations except the hypochlorites have proved unsatisfactory and have been discarded for the latter in this section of the country. Hypochlorites in the form of chloride of lime, Javelle's or Labaraque's solution (U. S. P.) and the well known proprietary preparations such as B. K., Chlorax, etc., are now recommended by the milking machine companies and generally used in California.

The two factors which constitute the vast majority of causes for discarding milking machines at the present time are: First, the increase in udder troubles, and second, the high bacterial count in machine drawn milk. The latter is of great importance where dairies are selling their product for market milk supply under a bacterial count grading system or where a premium is paid for sweet cream delivered to butter making plants.

Milking machine companies are themselves to blame for many machines being discarded because of the common practice of their selling agents to state that the machines need not regularly be taken apart for cleaning and that dipping in chlorine solution is all that is necessary.

Agents selling the proprietary chlorine preparations have been even more extravagant in their claims of the value of their solutions for sterilizing milking machine parts.

Ordinary chloride of lime (calcium hypochlorite-bleaching powder) contains about 25 to 35 per cent available chlorine which is the highest free chlorine content of any of these preparations. Javelle's or Labaraque's solution, United States Pharmacopeia, and the well known proprietary chlorine preparations contain from about 2.5 to 5 per cent available chlorine. They are clear solutions, however, and therefore much more easily mixed up ready for use than chloride of lime.

The power of chlorine solutions to act as a disinfectant depends first, on the available chlorine content and, second, on the chemical and physical properties of the material to be disinfected. Granting that the chlorine content is present, many observations in the dairy industry, under various conditions, have definitely shown that these solutions are not so efficient in the presence of a considerable accumulation of milk residue as when this has been properly removed by thorough washing.

For example, it has been demonstrated that chlorine solution run into the last rinse water tank in a milk bottle washing machine, in a high dilution, was remarkably efficient in reducing the bacterial content of the water and the finished bottles. The same or greater strength solution showed little efficiency when run over milk cooling apparatus, pipe lines and containers which were noticeably greasy when the hand was passed over them. This is probably due to its lack of penetrating power. The presence of organic matter such as milk residue rapidly deteriorates chlorine solution by using up the chlorine in oxidation. After all the chlorine is utilized, the disinfectant properties of such a solution are nil and bacteria may even multiply in it in great numbers.

To show the reduction in chlorine by oxidation in the presence of milk or rubber the following tests were made with the assistance of C. H. McCharles, Chemist of the State Food and Drug Laboratory. Three 1½ gallon glass jars were each partially filled with one gallon of water to which chlorine solution was added in the proportion of 3 ounces to 5 gallons. This is about the proportion usually recommended for milking machine parts. The chlorine solution before dilution showed 2.35 per cent available chlorine, and when added to the water in the above proportion, the fluid in the jars contained about one part of available chlorine to each 10,000 parts of water.

Jar 1 was not disturbed; jar 2 had 2 cc. of milk added daily; jar 3 had some rubber tubing placed in it.

Titrations for chlorine content were made each day, the results of which are shown in table 1.

Bacterial counts of the solution in jar 2 showed no growth on June 12 and 13. On June 19, ten days after mixing up the solution, it showed a bacterial content of 210,000 per cubic centimeter. Two cubic centimeters of milk had been added each day from June 9 to 17 inclusive.

A second test was conducted using only two jars. The solution was mixed in the same proportions. Jar 1 was left undis-

TABLE 1

	JAR 1	JAR 2	JAR 3
June 9, 1919	2.80 cc. 0.0099 gm.	0.90 cc. 0.0032 gm.	3.00 cc. 0.0106 gm.
June 10, 1919	2.80 cc. 0.0099 gm.	0.45 cc. 0.0016 gm.	1.30 cc. 0.0046 gm.
June 11, 1919	2.80 cc. 0.0099 gm.	0.30 cc. 0.0011 gm.	0.90 cc. 0.0032 gm.
June 12, 1919	2.70 cc. 0.0096 gm.	0.20 cc. 0.0007 gm.	0.65 cc. 0.0023 gm.
June 13, 1919	2.70 cc. 0.0096 gm.	0.20 cc. 0.0007 gm.	0.30 cc. 0.0010 gm.
June 14, 1919	2.70 cc. 0.0096 gm.	0.15 cc. 0.0005 gm.	0.15 cc. 0.0005 gm.
June 16, 1919	2.60 cc. 0.0092 gm.	0.10 cc. 0.0003 gm.	0.05 cc. 0.0001 gm.

cc. = cubic centimeters N/10 sodium hyposulphite equivalent to 100 cc. sample.

gm. = grams of available chlorine per 100 cc. of sample. The fourth decimal of the gram measurement represents parts of chlorine per million of solution.

turbed as a check and in jar 2 the rubber tubing was placed and also 2 cc. of milk daily. The results of this test are given in table 2.

A bacterial count of the solution in jar 2, made June 27, 1919, showed 600 bacteria per cubic centimeter.

These tests show that both milk and rubber reduce the chlorine content of solutions containing it. The more milk residue that

adheres to the tubing, the quicker the chlorine becomes utilized. Many crocks used for the solution on dairy ranches are of such a size that the tubing cannot lay out straight in them. It is the usual practice for the parts to be forced down under the solution so that there are bends in the tubing, in which case, air instead of solution may remain in contact with the lumen of the tubes. After use for some time the rubber tubing shows checking or slight cracks on its surfaces which can be enlarged and readily seen by distending the tubing. These crevices, although

TABLE 2

	JAR 1	JAR 2
June 19, 1919	3.45 cc. 0.0122 gm.	3.10 cc. 0.011 gm.
June 20, 1919	3.40 cc. 0.0121 gm.	1.55 cc. 0.0055 gm.
June 21, 1919	3.40 cc. 0.0121 gm.	0.60 cc. 0.0021 gm.
June 23, 1919	3.40 cc. 0.0121 gm.	0.20 cc. 0.0007 gm.
June 24, 1919	3.40 cc. 0.0121 gm.	0.15 cc. 0.0005 gm.
June 25, 1919	3.30 cc. 0.018 gm.	0.075 cc. 0.0002 gm.

hardly visible, become filled with milk during the milking and furnish innumerable points for bacterial multiplication out of reach of the chlorine solution which, as stated above, seems to have little or no power of penetration through a layer of milk residue.

As examples of the failure of this means of sterilizing rubber parts the following might be mentioned:

In 1913, a dairy using milking machines attempted to get dairy certification under the San Francisco Medical Milk Commission and failed to meet the bacterial requirements on account of depending on chemical sterilization of parts.

On October 1, 1916, the California state milk grading law went into effect. This law allows a maximum of 200,000 bacteria per cubic centimeter for grade "A" milk to be pasteurized and 1,000,000 bacteria per cubic centimeter for grade "B" milk to be pasteurized. This law was at once enforced in Los Angeles and dairies operating milking machines could not meet the bacterial requirements by using chemical solutions. The machines had to be discarded, the milk degraded to butter fat or the parts, including rubber tubing and inflations, sterilized by heat.

EXPERIMENTS TO SHOW THE PRACTICABILITY AND EFFICIENCY OF HEAT STERILIZATION

The early work of Stocking (3) with heat sterilization by placing the tubing on a steam jet, scalding just prior to use and boiling for three-quarters of an hour was found to be most efficient but not recommended on account of the destruction of the parts.

Edwards (13), in 1907, found boiling and proper cleaning efficient in keeping bacteria down. Haecker and Little (11) found lime water inefficient unless accompanied by boiling and painstaking cleanliness of parts. They stated that rubber tubing at the station dairy, subjected to daily boiling, remained in good condition for more than a year.

In spite of these definite conclusions that heat was essential, it has not been put into general practical use on account of the belief that the rubber would be injured. With the quality of rubber now in use it is possible to boil it daily for a considerable time without destroying its usefulness.

To test this, a piece of rubber tubing as supplied by one of the milking machine companies was boiled for twenty to thirty minutes each week day from December 13, 1917, to May 28, 1918, without injuring it to such a degree that it would not be usable. The inflations, however, are more susceptible to the destructive influences of heat than the tubing.

Realizing the great efficiency of pasteurization at 145°F. in destroying 95 to 99 per cent of the bacteria ordinarily present in milk, it was thought that some temperature between 145° F. and

212°F. could be found at which a pasteurization of milking machine rubber goods would render them practically sterile and yet prolong the usefulness of the rubber for a longer period than when subjected to boiling.

Experiments with heat sterilization were begun on dairy "A." This is a large dairy milking about 200 cows and supplying a "guaranteed" milk to the San Francisco Bay cities. The bacterial limit of this grade of milk is 25,000 per cubic centimeter. The Sharples milking machines were in use. The original plan of sterilization of the parts on this dairy was to put the tubes and teat cups in a low pressure steam sterilizer, but depreciation of the rubber was rapid. A galvanized iron tank, 4 feet long, 1 foot wide and 1½ feet deep, without any lid, was then installed and the parts placed in water in the tank and the temperature raised by steam to between 160° and 180°F. for fifteen to twenty minutes. A series of bacterial counts were made on the parts so sterilized and on the milk drawn by the machines.

In this work the tests of the sterility of the parts were conducted by running sterile water through the apparatus to be tested. The amount of water used in each test was 100 cc. Plates were made according to the standard methods of the American Public Health Association from the rinsings.

In the first series of counts on the sterility of the apparatus the plates made from the teat cups and connected rubber tubing showed colonies too numerous to accurately count in the undiluted rinse water. The pails were also unsterile but the rinse water from them did not contain as many bacteria as that from the rubber ware. One milk pail and one stripping pail showed 197 and 653 bacteria per cubic centimeter of rinse water, respectively, which were the lowest counts obtained. A second series of similar tests were made November 12, 1917, except that the rinse water was diluted 1–100 before plating. Twelve samples of water run through the teat cups and connected rubber tubing showed bacterial counts ranging from 205 to 24,200 per cubic centimeter. At the conclusion of this test a lid was ordered for the sterilizer tank and a definite temperature of 180°F. for fifteen to thirty minutes was maintained and followed as a routine pro-

cedure. On December 13, 1917, a third series of counts were made. Five sterile rinse water samples were run through the connected apparatus. The counts on these rinse water samples, using 1 cc. undiluted in making the plates, ranged from 6 to 60 bacteria per cubic centimeter.

The bacterial counts of the milk drawn through this apparatus on the different dates are given in table 3.

One sample of bottled milk was taken on November 5 which showed 11,500 bacteria per cubic centimeter.

TABLE 3

SAMPLE FROM	COUNT 1ST UNIT	COUNT 2D UNIT	COUNT 3D UNIT	STRIPPINGS	DATE
1st pail milk	24,300	5,700	10,300	26,200 1st string	November 5, 1917
2d pail milk	7,000	12,600	9,500	23,100 1st string	November 5, 1917
3d pail milk	5,400	8,800	12,800	7,600 2d string	November 5, 1917
4th pail milk		7,400	5,700	70,900 3d string	November 5, 1917
5th pail milk	7,200	9,000		26,000 3rd string	November 5, 1917
1st pail milk	7,300	2,450	7,700	9,000 1st string	November 12, 1917
2nd pail milk	2,450	1,800	1,750	17,500 3rd string	November 12, 1917
3d pail milk	2,900	4,250	500	16,000 2d string	November 12, 1917
1st pail milk		7,500	900	No strippings	December 13, 1917
2d pail milk	3,500	4,750	1,850	taken	December 13, 1917
3d pail milk	3,000				December 13, 1917

The milk counts on November 5 and 12 show that the sterilization, even though very incomplete, was sufficient to produce a milk well under 25,000 bacteria per cubic centimeter, the limit for the grade.

An examination of table 3 will show little change in the bacterial count of the milk on December 13, even though the tubes and teat cups at this time were practically sterile. This is accounted for by the dilution of the bacteria on the previous occasions with the large volume of milk and the fact that the actual number of bacteria in the rubber tubes and teat cups, even though not countable when 1 cc. of undiluted rinse water was plated as in the first series of tests, was relatively small.

In the spring of 1918 scarcity of labor made it necessary for dairy "B" to put in milking machines. This is a certified dairy milking 225 cows, the product of which is sold in San Francisco and the maximum count of this grade is 10,000 per cubic centimeter. The step was taken with considerable apprehension for fear the quality of the product would be reduced.

From the experience gained with dairy "A," this dairy was advised to and did install a galvanized iron tank similar to that described on dairy "A" for sterilizing the rubber parts of the machines.

On this dairy both the Empire and Perfection milking machines were in operation from the beginning. The method of cleaning the machines was as follows. Each unit was attached to the suction line and a vacuum established in the pail. The teat cups were then alternately raised and lowered into a pail of water with the pulsator running. Three to four gallons of water were run through the machines in this manner to clean out the milk. The rubber parts were then disconnected from the pails and the teat cups and short rubber tubes taken off the claw to facilitate brushing. At first, the inflations were taken out of the teat cup shells but this was soon stopped on account of the difficulty of reassembling. All parts were placed in warm water containing soda ash cleaning powder and scrubbed both ways with long brushes for this purpose. They were then rinsed in clear water to remove the soda ash and reassembled ready for use. A plug was inserted in the air line at its junction with the claw and the whole placed in the sterilizer. Water was run in until they were submerged and the pulsator lids were placed on top of the rubber tubing in such a way as to hold it down in the water and at the same time prevent the pulsator from getting flooded. Those machines that have the pulsator slightly elevated or off the lid entirely have an advantage in that there is no danger of getting water in the delicate mechanism. Occasionally a lid will warp in this process of sterilizing, after which it will no longer make a tight fit on the pail and a vacuum cannot be secured.

The cover was placed on the sterilizer and the steam turned on till the temperature reached 190°F., where it was maintained

for fifteen to thirty minutes. After sterilization was completed, the water was allowed to cool and the contents left undisturbed in the tank until the next milking time.

Further investigation is necessary to definitely determine whether it is better to remove the tubes or leave them in the water. Some evidence is present to show that keeping them moist prolongs their period of usefulness over allowing them to dry quickly after sterilizing. From the bacteriological standpoint no difficulty has been experienced with undestroyed bacteria multiplying after an optimum temperature is reached.

In May and June, 1918, a series of bacterial counts were made at dairy "B" as shown in table 4. On this dairy each machine unit milks 45 cows.

The tinware on this ranch is regularly sterilized in an autoclave under pressure. In all, 113 samples of machine milked milk were collected and counted. Two samples were over 10,000; the highest being 18,000.

During the year from June 1, 1918, to June 1, 1919, the highest count that was obtained in official samples for dairy "B" was 15,500 and an average of all samples taken was 6000. The rubber parts on this dairy have remained in use from two to four months—the tubes being longer lived than the inflations.

The following experimental work was conducted on dairy "C." This dairy was of the type of the ordinary market milk dairy, operated by a Portuguese dairyman and the milk shipped to be pasteurized in San Francisco. Perfection type of milking machines were in use. The general practice of cleaning the machines was to rinse out the milk with cold water by letting the machines run with the teat cups immersed in a pail of water. The long tubes and teat cups were brushed in warm water containing a cleaning powder but the teat cups were not disconnected from the claw. The air line was plugged and the whole coiled in a large earthenware jar containing B. K. solution between milkings. No careful sterilization of the tinware was done, although a boiler and steam jet were present for the purpose.

A bacterial count was made daily with few exceptions from November 1, 1918, to January 20, 1919. The sample was al-

TABLE 4

	Sample of						
	1st unit	2d unit	3d unit	4th unit	5th unit	Hand strip	
May 21, 1918							
Rinsings of teat cups	1	0	1	0	0		
1st pail milk	3,200	2,100	18,000	1,150	6,400	5,700	
2d pail milk	4,500	3,150	3,150	2,250	1,000	1,650	
3d pail milk	2,950	4,700	2,250	5,100	2,550	7,650	
May 23, 1918							
Rinsings of teat cups	3	2	4	2	5		
1st pail milk	2,300	2,300	9,550	2,450	450	17,500	21,400
2d pail milk	12,750	700	3,400	1,250	350	4,600	7,550
3d pail milk	2,750	1,500	1,900	3,550	2,400	3,800	7,600
4th pail milk		3,400		2,300		1,150	10,600
						5,800	
						900	
						8,300	
May 28, 1918							
Rinsings of teat cups	8	0	4	10	12		
1st pail milk	1,800	1,300	1,750	1,000	500		
2d pail milk	300	900	1,000	1,100	350		
3d pail milk	1,250	500	4,500	9,900	300		
4th pail milk	2,750	1,100	1,850	250	650		
5th pail milk	3,550	500	3,600	1,100	3,800		
6th pail milk	1,950		1,050	850	350		
7th pail milk	6,400		2,550	500			
May 31, 1919							
Risings of teat cups	15	7	6	4	22		
1st pail milk	1,250	3,200	2,100	1,050	1,550		
2d pail milk	4,950			750	400		
3d pail milk	1,000	1,350	2,500	1,850	1,000		
4th pail milk	2,000	500	3,800	650	1,400		
5th pail milk	2,800	2,700	3,100	1,000			
June 5, 1919							
Rinsings of teat cups	14	4	1	7	25		
1st pail milk	900	1,600	1,000	427	2,150	1,450	
2d pail milk	6,350	4,925	2,875	500	1,000	10,200	
3d pail milk	350	4,350	1,700	650	850	1,100	
4th pail milk	900	900	4,075	250		1,400	
5th pail milk	3,825	750	2,100	700		2,050	
6th pail milk	700	400	1,525	1,300			

ways taken from the pasteurizer vat before heating, after the night's milk eighteen hours old and the morning's milk seven hours old had been mixed in it. The counts are given in table 5

TABLE 5

Bacterial counts of machine milked milk on an ordinary dairy

	NOVEMBER	DECEMBER	JANUARY 1 TO JANUARY 20, 1919
Bacteria per cubic-centimeter of milk	99,300,000	3,000,000	1,960,000
	25,300,000	3,360,000	2,630,000
	38,300,000	2,830,000	526,000
	7,460,000	1,146,000	2,930,000
	9,700,000	6,640,000	1,300,000
	4,500,000	3,130,000	2,700,000
	2,830,000	12,960,000	3,730,000
	1,123,000	6,130,000	8,130,000
	940,000	4,300,000	5,000,000
	400,000	5,560,000	850,000
	2,700,000	236,000	1,543,000
	3,160,000	760,000	
	1,930,000	2,000,000	
	8,700,000	2,000,000	
	39,300,000	1,060,000	
	14,600,000	213,000	
	3,800,000	230,000	
	5,600,000	930,000	
	9,000,000	1,126,000	
	41,000,000	1,123,000	
	58,000,000	2,160,000	
	20,000,000	5,360,000	
	39,000,000	810,000	
	37,600,000	1,445,000	
	29,000,000	1,860,000	
	13,000,000	3,760,000	
	2,460,000	7,900,000	
	6,230,000	2,230,000	
	6,330,000	1,600,000	
	1,360,000	1,800,000	

and show excessive numbers of organisms on nearly all the days during this period.

The excessive bacterial count of the milk caused one of us (S.) to visit the ranch in January, 1919. An inspection of the rubber parts of the milking machines showed milk residue where

the milk came in contact with them in the process of milking. The chlorine solution for the rubber parts did not seem to be freshly made up or made according to direction, although the dairyman insisted that he had followed directions in making and using it.

TABLE 6

Bacterial counts of machine milked milk after instructions in cleaning and steaming tinware had been given

	MONTH BEGINNING		
	January 21	February 1	March 3
Bacteria per cubic centimeter of milk	250,000	1,416,000	8,160,000
	1,180,000	1,580,000	7,630,000
	1,130,000	4,260,000	6,300,000
		4,360,000	6,600,000
		4,130,000	2,760,000
		4,800,000	
		7,130,000	
		14,730,000	
		4,000,000	
		4,960,000	
		7,560,000	
		8,100,000	
		6,130,000	
		6,200,000	
		8,530,000	
		19,600,000	
		22,600,000	
		1,300,000	
		1,030,000	
		9,000,000	

The tinware was in a poor state of repair, especially the large receiving tank, in the bottom seam of which a small leak had been stopped with soap. The insides of the utensils were greasy to the touch.

The tinware was soldered, fresh chlorine solution mixed up for the machine parts, and methods improved in a general way. This resulted in little improvement in the quality of the milk as can be observed by referring to the bacterial counts obtained from January 21 to March 10, given in table 6.

The dairyman was then requested to put in a sterilizer tank similar to the one in use at dairies "A" and "B." The rubber parts of the machines were to be put in once daily and the temperature brought to 180°F. for fifteen to thirty minutes. It was thought that sterilizing in this way once a day would reduce the count so that the milk would meet the bacterial requirements

TABLE 7

Bacterial counts of machine drawn milk after rubber parts were sterilized by heat

	MARCH 11	APRIL 1	MAY 1	JUNE 2
Bacteria per cubic centimeter of milk	200,000	150,000	180,000	230,000
	160,000	200,000	120,000	160,000
	106,000	260,000	96,000	140,000
	210,000	180,000	52 000	170,000
	216,000	200,000	100,000	110,000
	150,000	207,000	230,000	190,000 *
	250,000	83,000	167,000	210,000 *
	155,000	130,000	190,000	220,000 *
	150,000	300,000	120,000	207,000
	340,000	200,000	110,000	205,000
	220,000	219,000	190,000	187,000
	320,000	150,000	210,000	211,000
	300,000	170,000		173,000
	87,000	230,000		198,000
	160,000	203,000		215,000
	150,000	190,000		240,000
		160,000		190,000
		79,000		200,000
				213,000
				184,000

* June hot spell.

for grade "A" raw, to be pasteurized, which in this state is 200,000 per cubic centimeter. The tank was installed and operated the first time March 10, 1919, and the immediate effect of this method of heat sterilization of milking machine parts can be observed by referring to table 7.

UDDER TROUBLES

We have no positive evidence of sterilization of milking machine parts reducing udder troubles and what we have to offer is in the nature of negative evidence. It is a well known fact

that pyogenic cocci and some members of the colon group are the organisms largely responsible for mammitis. These organisms are widespread in nature. Many outbreaks of mammitis have developed in dairies where machine milking has been done and the fact that udder troubles had become more frequent than was the case with hand milking, caused many dairymen to discard the milking machine after a few months or years of use. The development of udder troubles has resulted in investigation by the manufacturers of milking machines, their selling agents, milk inspectors and others interested. The universal findings in such investigations have been an unsanitary condition of the teat cups and rubber tubing. While the same conditions undoubtedly do occur on many ranches without seeming to cause udder troubles, the fact remains that several hundred cows under our observation have now been milked with machines properly sterilized for from one to several years and no increased udder troubles have developed. Practically sterile teat cups may, therefore, be an insurance against this potential danger.

CONCLUSIONS

1. Heat sterilization is the only way to successfully sterilize milking machine rubber parts under ordinary ranch conditions.
2. It is a practical procedure from the time involved and the wear and tear on parts.
3. Where it has been regularly done no increased trouble with mammitis has ever developed as a result of installing machines.
4. By this means as low a bacterial count milk can be produced with milking machines as by hand milking.
5. Milk can be produced to meet any reasonable bacterial grading system.
6. No chemical solution has been found to successfully accomplish these results under practical conditions.
7. Its general application will greatly reduce the discarding of milking machines after they have been installed.

REFERENCES

(1) HARRISON, F. C. Machine drawn milk versus hand drawn milk. Some bacteriological considerations. 23d Annual Report of the Ontario Agricultural College and Experimental Farm, 1897, pp. 128–132.

(2) BORDAS, F., AND DE RACZKOWSKI: De la traite micanique, dans l'industrie laitiere. Paris Academie des Sciences Comptes Residus, 1902, 135, pp. 371–372.

(3) STOCKING, W. A.: Bacteriological studies of a milking machine. U. S. Dept. of Agriculture Bulletin 92, pt. 2, 1907.

(4) ERF, OSCAR: Milking machines. Kansas Agricultural Exp. Sta. Bulletin 140, 1906.

(5) STOCKING, W. A., AND MASON, C. J.: Milking machines. Effect upon quality of milk. Connecticut Ag. Exp. Sta. Bulletin 47, 1907, pt. 1.

(6) HASTINGS, E. A., AND HOFFMAN, CONRAD: Bacterial content of machine drawn and hand drawn milk. Wisconsin Ag. Exp. Sta., 24th Annual Report, 1906–1907.

(7) MEEK, ELIZABETH B.: Bacterial efficiency of the milking machine. Penn. Ag. Exp. Sta. Annual Report, 1907–1908, p. 146.

(8) BRAINARD, W. K.: The production of clean and sanitary milk. Virginia Ag. Exp. Sta. Bulletin 185, 1909.

(9) HARDING, H. A., WILSON, J. K., AND SMITH, G. A.: Milking machines. Effect of method of handling on the germ content of the milk. New York Ag. Exp. Sta. Bulletin 317, 1909.

(10) WING, LOIS W.: Milking machines: their sterilization and their efficiency in producing clean milk. Cornell Ag. Exp. Sta. Circular 18, 1913.

(11) RUEHLE, L. A., BREED, R. S., AND SMITH, G. A.: Milking machines. III. As a source of bacteria in milk. IV. Methods of maintaining in a bacteria free condition. New York Ag. Exp. Sta. Bulletin 450, 1918.

(12) HAECKER, A. L., AND LITTLE, E. M.: Milking machines. Nebraska Ag. Exp. Sta. Bulletin 108, 1908.

(13) EDWARDS, S. F.: Bacteria and the Burrell Lawrence Kennedy milking machines. Ontario Dept. of Ag. Bulletin 159, 1907.

THE DEVELOPMENT OF ACIDITY IN MILK

DAN W. STEUART

University College, Cardiff, Wales

The development of acidity in milk is a biological phenomenon which offers many very interesting but obscure problems for those to solve who are interested in scientific dairying.

Milk fresh from the cow has an amphoteric action on litmus papers but is distinctly acid to phenolphthalein solution. The acidity of milk is usually estimated, using 10 cc. of undiluted milk, by titration with sodium hydroxide solution with phenolphthalein as indicator, and the acidity is then calculated as lactic acid. By this means Koning has shown that the acidity of fresh milk from individual cows varies from 0.10 to 0.21 per cent (1). This agrees very well with the work of other investigators; but on the question of the *average* acidity of fresh milk writers disagree a little; it varies apparently with locality and other factors.

The cause of the natural acidity of milk has been the subject of some experiment. It is evidently not due to lactic acid (2).

Commercial milk in Cardiff has usually an acidity between 0.16 and 0.20 per cent and it may contain from 20,000 to 1,500,000 bacteria per cubic centimeter (counted on ordinary agar plates after three days at blood heat).

When milk is retained for some time the acidity increases due to the production of acids from the milk sugar by bacteria. This increase does not always immediately become apparent. The milk may show no increase of acidity for a period of time which has been called the "incubation phase." This incubation phase lasts longer the lower the temperature and seems to be associated in some way with a "bactericidal phase" during which the initial bacteria, or some of them, decrease in number. The acidity of the milk may actually decrease for a time (3).

Finally, then, the acidity increases and when it reaches about 0.3 per cent the milk will curdle on boiling. When it reaches

somewhere between 0.60 and 0.86 per cent the milk coagulates spontaneously.

By and by the acidity of the milk reaches a maximum, which varies according to the temperature at which the milk has been held; then the acidity gradually decreases. These changes in the acidity of the milk must be correlated with the development of bacteria in it and the biology of this matter is extremely complicated. First one type of bacteria reaches its maximum numbers and then another and we have thus a sort of rotation of germ crops in the milk.

The change in the acidity of Cardiff milks retained at three different temperatures are shown in the accompanying graphs.

The milks were placed in sterilized Erlenmeyer flasks plugged with sterile cotton wool and from week to week portions were withdrawn and titrated in the usual way. After the milk curdled instead of measuring it with a pipette, a 10 cc. glass cylinder was used which was then washed out with a *small* quantity of water into the titration flask.

In cold storage it will be seen that the acidity increases somewhat slowly and that the maximum attained is just about 1 per cent. At blood heat the acidity increases very much quicker and may attain as much as 3 per cent in one week. The lowest acidity reached in one week at this temperature was 1.6 per cent. At room temperature the acidity increases at an intermediate pace but the maximum attained varies very greatly, anything from 1 per cent to over 2 per cent. The explanation of these results lies in the type of germ which is encouraged.

The principal acid producing bacteria in milk may be conveniently divided into four groups (Löhnis) as follows:

1. The lactic streptococci group. These are short rods, or oval cocci in pairs or in chains. They produce up to 1 per cent of acidity in milk. Their optimum temperature varies enormously but is usually about 82°F. Some grow better at room temperature than at blood heat while the contrary may be the case. They grow slowly in cold storage. They constitute the ordinary starters used in this country for ripening cream to make butter, or ripening milk to make cheese. They generally constitute

about 99 per cent of the total bacteria in milk which has just curdled at room temperature, in well ripened cream, or in green cheese a few days old. They curdle milk producing a homogeneous curd with a pleasant acid taste. They produce tiny little colonies on solid culture media such as litmus lactose agar. acidification is greater in the depths of the milk culture showing that they are somewhat anaerobic. A good strong culture of these germs seeded into pasteurized milk should produce an acidity of 1 per cent in twelve hours at 72°F. (with a 1 per cent inoculation).

2. The intestinal lactic bacteria. These originate from excrement and B. coli belongs to this group. They curdle milk giving a curd with an unpleasant sour smell, and the curd is pitted with gas holes. They are a cause of gassy curd or blown cheese. They spoil both cheese and butter. They are commonly overnumerous in milk which has been ripened without the aid of a good starter. A culture of B. coli here gave a maximum acidity of 0.75 per cent at room temperature or at blood heat. It grew slowly in cold storage. They are short rods and B. coli is motile; the other members of the group are usually non-motile. They are always objectionable but tend to be outgrown by members of groups 1 and 3 which can produce a higher acidity if the conditions are suitable. They produce well marked colonies on ordinary solid media. They are somewhat aerobic and grow best about blood heat.

3. The lactobacilli. These are usually long thin rods. They are used as starters in making the Emmenthal-Gruyère type of cheese, and also Grana (Parmesan) cheese. To this group belongs the well known Bacillus bulgaricus. Their properties vary. B. bulgaricus from "lactigen" produces very high acidities at blood heat (3 to 3.5 per cent). They do not grow on ordinary solid media. Their optimum temperature is usually well above blood heat. A 1 per cent inoculation of "lactigen" into pasteurized milk will produce about 1.2 per cent of acidity in twelve hours at 98°F.

4. The lactic micrococci. This is a somewhat indefinite group of acid producing bacteria which are principally found in milk that has been held in cold storage. They have been found

inside the udders of cows so do not necessarily get into milk from dust or dirt. They have been found in butter and cheese and their optimum temperature is said to be low.

All these four groups of lactic bacteria are found in commercial milks and we are now able to see why milk kept at blood heat develops so much acidity; it is because the lactobacilli develop quickly and strongly. They do not develop in cold storage and they may or may not develop at room temperature. Their minimum temperature is usually supposed to be about 68°F.; but it varies with different strains (4).

Thus three lots of milk, each containing lactobacilli as shown by the blood heat incubations, were kept at room temperature and were subject to the same temperature variations, yet the maximum acidities attained varied greatly as the following data show:

Commercial milks held at room temperature

	A	B	C
	Bacteria per cubic centimeter.		
	800,000	230,000	580,000
	per cent	*per cent*	*per cent*
Acidity at start	0.19	0.16	0.18
Acidity in 2 days	0.86	0.86	0.86
Acidity in 1 week	1.00	1.07	1.00
Acidity in 2 weeks	1.03	0.97	1.09
Acidity in 3 weeks	1.12	1.30	1.52
Acidity in 4 weeks	1.11	1.16	1.80
Acidity in 5 weeks	0.88	1.12	2.20
Acidity in 7 weeks	0.70	0.65	

Apparently the lactobacilli did not develop in A, doubtful in B, and they certainly did in C. When the acidity of milk exceeds 1.25 per cent it can usually be proven that lactobacilli are present (5). Other maximum acidities obtained at room temperature have been 1.17 per cent, 1.40 per cent and 2.01 per cent.

From time to time the aging milks were inoculated at the rate of 1 per cent into flasks of sterilized milk and held at 98°F. The subcultures from milk kept at 98°F. always attain a high degree of acidity:

NUMBER	ORIGINAL AT 98° F.		SUBCULTURE AT 98° F.	
	Age	Acidity	Age	Acidity
	days	*per cent*	*days*	*per cent*
1	14	2.66	5	1.94
2	14	3.19	5	1.89
3	35	2.90	7	1.73
4	105	0.88	7	1.98

In each case the subcultures developed over 1.7 per cent of acidity and then the acidity rapidly fell. Microscopic examination showed the presence of lactobacilli and yeasts. Ordinary agar plates grown at room temperature from one of the subcultures showed only yeasts. The reduction of the acidity was accordingly attributed to the yeasts. The odor of the subcultures was alcoholic, or aromatic suggesting esters, or sometimes cheesy. The originals often smelt malty. The most interesting subculture was that made from the milk retained fifteen weeks at 98°F. The acidity had reached 3.2 per cent on the sixth week but fell to 0.88 per cent in the fifteenth week. Nevertheless the subculture then made showed that the lactobacilli were still alive in the milk. One of these subcultures containing yeasts and lactobacilli gave a badly blown cheese curd smelling strongly of alcohol (6).

Subcultures from milks at room temperature also gave interesting results:

NUMBER	ORIGINAL AT ROOM TEMPERATURE		SUBCULTURE AT 98° F.	
	Age	Acidity	Age	Acidity
	days	*per cent*	*days*	*per cent*
1	14	0.99		Never above 1
2	14	0.99		Never above 1
3	35	1.34	12	1.41
4	105	0.92	7	1.65

Here again the most interesting culture is the fourth where the milk held at room temperature had reached an acidity of 2.01 per cent in six weeks but decreased to 0.92 per cent on the

fifteenth week; yet the subculture showed that the lactobacilli were still alive and active.

Subcultures made from milks held in cold storage for seven to fifteen weeks never at any time showed over 1.26 per cent of acidity when incubated at blood heat for seven days, and two of them kept till fourteen days showed then a decreasing acidity.

These results indicated that lactobacilli are invariably present in Cardiff milks, that they may or may not develop at room temperature, and that when they do develop the high acidity they produce favors the growth of yeasts which subsequently reduce the acidity. This agrees with the results obtained by Orla Jensen, Rosengren and others on the bacteriology of butters; high acidities favor the yeasts which subsequently deteriorate the butter.

A sample of milk kept at room temperature for five weeks showed a maximum of 1.17 per cent of acidity and on the ninth week the acidity fell to 0.92 per cent. Whey agar plates then made from the milk were rapidly overgrown (two days) at 98°F. by oval spore formers; while gelatine plates were liquefied. Similar plates are often made from boiled hay. The sample of milk was then thoroughly pasteurized to kill yeasts, moulds and non-sporing bacteria and held at 98°F. for a week. During that time the acidity dropped from 0.92 to 0.60 per cent. The reduction of the acidity in this case was not due to yeasts but to spore-forming rods which were found to be capable of producing a badly blown cheese curd (7). Subcultures in liquid media showed the presence of long rods with an undulating motility. They produced 1.1 per cent of acidity in milk at blood heat in three weeks.

Other organisms sometimes taking part in the final reduction of the acidities were moulds—Oidium lactis, Penicillium, etc. In one case a milk held four weeks at blood heat went into a solid lump with moulds so that no further acidity estimations were possible.

The four groups of lactic bacteria already referred to do not form spores and so do not survive pasteurization. When milk is pasteurized spore-forming rods survive. When held subse-

quently at almost any temperature within reasonable limits these milks finally curdle and at that time may or may not show an increase of acidity compared with the fresh milk. The curd, however, begins to digest and the acidity of the milk will then rise.

Three samples of pasteurized milk were kept for three weeks in cold storage yet the acidity did not exceed 0.18 per cent in any case and the milks did not curdle on boiling. Two samples of one milk were pasteurized thoroughly in boiling water and then cooled and kept at blood heat. They curdled in three days when one showed an acidity of 0.18 per cent; the acidity of the other in sixteen days when the curd was almost completely digested was 0.45 per cent. Two samples of the one milk were pasteurized, the first at 165°F. for five minutes, and the other at 210°F. for fifteen minutes. In fourteen days at blood heat the acidity of the first reached 0.83 per cent and of the other 1.03 per cent. These cultures smelt like strong cheese. Some of these spore formers can evidently produce a fair degree of acidity in milk. In raw milks they are held in check by the lactic bacteria; but if the lactobacilli do not develop, and since the streptococci die out fairly rapidly after reaching their maximum numbers, the spore formers may then get an opportunity to develop in the old milk as has already been shown.

These experiments, carried out at the King Edward VII Hospital, Cardiff, were designed to cast some light on the bacteriology of the keeping properties of butter, and of the ripening of cheese; but the subject has proved immensely complicated. They may however serve to interest others in a most interesting subject which has been rather neglected in this country.

In the University College Dairy we used ordinary starters of lactic streptococci to ripen the milk for making Cheddar cheese. On two occasions, when starter was being added to the milk at the rate of 2 per cent, experimental cheeses were made in which half the starter was replaced by a culture of B. bulgaricus (lactigen). The resulting truckle Cheddars when ripe differed in no way (neither in flavor nor in texture) from the control cheeses made on the same day.

A fairly complete summary of the earlier experiments on this subject will be found in Lafar's Handbuch der Technischen Mykologie, and Dr. Fascetti has an original article on "The principal and most recent applications of bacteriology to the dairying industry" in the International Review of Agriculture, of February, 1915.

REFERENCES.

(1) KONING: Biologische und Biochemische Studien über Milch, Leipzig, 1906, p. 53.
(2) VAN SLYKE AND BOSWORTH: New York Exper. Sta. Bull. 37, 1914; also Koning, loc. cit.
(3) KONING: loc. cit., p. 20.
(4) FREUDENREICH AND THONI: Landw. Jahr. der Schweitz, vol. 18, p. 525; also Rogers, Fermented milks, U. S. Dept. Agric., Bur. Animal Ind. Bull. 319, p. 21.
(5) HASTINGS, EVANS AND HART: The bacteriology of Cheddar cheese, U. S. Dept. Agric., Bur. Animal Ind. Bull. 150, p. 32, 1912.
(6) U. S. Dept. Agric., Bull. 148, p. 13.
(7) DAIRE: Les microbes dans l'industrie laitière, 1914, p. 113.

Thomas Corneliuson

Thomas Corneliuson, dairy manufacturing specialist of the Dairy Division, U. S. Department of Agriculture, died on October 3, 1919, at Belleville, Wisconsin, after a lingering illness of six months. Mr. Corneliuson, who has long been active in dairy work throughout the United States, leaves a host of friends who will mourn this new loss to the dairy industry.

Up to the time of his illness Mr. Corneliuson was in active charge of the inspection of the large quantities of butter produced for the United States Navy, and also directed the inspection of the renovated butter produced in this country.

Mr. Corneliuson, who was born in Denmark, April 18, 1865, received his early training in creamery work in that country. After serving several years as student and buttermaker in Danish creameries he decided that the United States held greater opportunities in store for him and accordingly came to this country in 1890. While connected with creameries in this country he attended the dairy school at the University of Wisconsin, completing several short courses and serving as instructor in buttermaking.

The thoroughness of Mr. Corneliuson's work and his remarkable memory for details soon won recognition, and in 1904–5 he was made a travelling cream instructor under the auspices of the Wisconsin State Dairymen's Association. The following year he became State Creamery, Dairy and Food Inspector for the Dairy and Food Commission, Madison Wisconsin, and continued in this capacity until 1908, when he was appointed to a responsible position with the United States Dairy Division.

Besides being an expert buttermaker, Mr. Corneliuson was one of the foremost butter judges of this country and rendered great service in this capacity. Conscientious, thorough and always striving upward, Mr. Corneliuson has won many staunch friends who will deeply regret his death.

Mr. Corneliuson was buried in Glenwood Cemetery, Washington D. C., on October 11, 1919, the services being conducted by the Lafayette Lodge of F. A. A. M., and DeMolay Commandery of Knights Templar, both of Washington, D. C.—*Helmer Rabild.*

ANNUAL MEETING OF THE AMERICAN DAIRY SCIENCE ASSOCIATION[1]

The annual meeting of the Dairy Science Association was opened at eleven o'clock in the Stock Yards Inn. After a few brief opening remarks by President Anderson the report on constitution was made the first order of business.

The report made by Chairman Eckles follows:

Proposed Constitution for Dairy Science Association

Article 1. The name of this organization shall be the American Dairy Science Association.

OBJECT

Article 2. The object of the Association shall be to advance the general welfare of the dairy industry, especially by the improvement of dairy instruction, by the stimulation of scientific research in all phases of the subject and by the improvement in methods of conducting extension work.

MEMBERSHIP

Article 3. Membership shall be of two kinds, active and associate.

Article 4. The following are eligible for election as active members:

(1) Any person who is formally announced by an Agricultural College, or Experiment Station or by the Dairy Division of the United States or Canadian Departments of Agriculture as an instructor, extension worker, investigator, or administrative officer connected with the dairy industry.

(2) Any one filling a position of responsibility connected with the dairy industry of a professional character requiring technical scientific training.

Article 5. An active member ceasing active duties in connection with the dairy industry is transferred to associate membership. Any person interested in the dairy industry but not eligible under the

[1] Credit is due President A. C. Anderson and Secretary N. W. Hepburn for the following report of the annual meeting of the American Dairy Science Association.—J. H. Frandsen, *Editor*.

qualifications as prescribed for active membership may be nominated for associate membership. Associate members shall be entitled to all the privileges of the Society except that of voting.

Article 6. Nominations for active or associate membership shall be submitted to the executive committee in written form and signed by at least three active members. Upon receiving the unanimous endorsement of the executive committee and paying the annual membership dues, the candidate shall be duly enrolled as a member of the Association.

OFFICERS

Article 7. The officers of this Association shall be president and vice-president, whose term of office shall be one year; a secretary-treasurer and a journal editor, whose term of office shall be two years. The term of office shall begin January 1.

The president, the vice-president, the secretary-treasurer and the presiding officers of divisions of the Society shall constitute the executive committee.

DUTIES OF OFFICERS AND MANNER OF ELECTION

Article 8. The duties of the officers shall be those usually pertaining to their respective offices. The executive committee shall pass upon all nominations for membership, all applications for divisions and sections of the Society. It shall have the power to fix the time and place of the annual meeting, and, shall be authorized to transact such business of the Association as demands attention while the Association is not in session.

Article 9. On or before November 1 the secretary shall mail to each member a blank upon which he shall be entitled to express his choice for each office to be filled. This blank shall give the names of those serving in the offices to be filled for five years preceding. All ballots shall be counted by the secretary and later verified by the president. In case no candidate has a majority by the first ballot, a second ballot shall be sent to the members giving the names of the three leading candidates for each office and the number of votes received. The candidate receiving the most votes on the second ballot shall be declared elected. In case of a tie on the second ballot the decision shall be made by the executive committee.

ORGANIZATION OF DIVISIONS AND SECTIONS

Article 10. Professional groups based upon geographical considerations to be known as divisions of the Society and to be organized by members of the Association may be authorized by the executive committee when such action shall seem expedient. The officers of the division shall be a chairman and such other officers as are provided by the division. The presiding officers of division shall be ex-officio vice-presidents of the Society.

The divisions shall have the right to make by-laws for its own government and which shall not be inconsistent with the constitution and by-laws of the Association.

Membership in divisions of the Society is open only to those regularly elected members of the Society.

Any division may raise or collect funds to be expended for its own purpose.

Article 11. Professional groups based upon specialized interests to be known as sections of the Society and to be formed by not less than ten active members may be authorized by the executive committee when considered for the best interests of the Association.

Such sections may elect their own officers and make any rules for their own guidance not inconsistent with the constitution and by-laws of the Association.

AMENDMENTS

Article 12. This constitution may be amended by a two-thirds vote at any regular meeting of the Association; provided the proposed amendments have been submitted to the executive committee in writing not less than thirty days previous to the meeting at which the vote is taken; and provided the proposed amendment is approved by a majority of the executive committee.

Article 13. The executive committee may at its discretion, submit proposed amendments which have received the approval of the committee to the members of the Association for vote by mail. An affirmative vote of two-thirds of all voting and which shall be not less than a majority of the membership shall be necessary for approval.

BY-LAWS

Article 1. The membership dues shall be $3 a year for both active and associate members, payable January 1 each year.

Article 2. The JOURNAL OF DAIRY SCIENCE shall not be sent to any member whose dues are not paid by April 11 of the year for which membership is held.

Article 3. Any member in arrears for dues for more than one year shall thereby cancel membership but may be restored to membership without any action by the Society by payment of all arrears including dues for the current year.

Article 4. The time and place of the meetings of the Society shall be fixed by the executive committee.

Article 5. A quorum at any meeting for the transaction of business shall consist of not less than 10 per cent of the active members.

Article 6. These by-laws may be amended at any regularly called meeting by a two-thirds vote of those present.

Action on report on constitution

Moved by Eckles, seconded by Cooper that the amendments to the constitution be adopted as read.

Moved by Wing, seconded by Stocking that membership plan no. II be adopted.

Above motion put to vote. Carried.

Moved by Eckles that present officers hold over to January 1. Carried.

Next the report on relation to Breed Associations was called for. Professor Eckles, chairman of this committee, made the report which follows:

REPORT BY COMMITTEE ON RELATION TO BREED ASSOCIATIONS

WHEREAS, the Superintendent of Advanced Registry of the Holstein Friesian Association of America, in reviewing the tests of semi-official records as reported by the Experiment Stations, has adopted a practice by which tests for individual months are rejected and averages for the preceding and succeeding months substituted, thereby either increasing or decreasing the particular record in question.

Be it resolved that this organization go on record as being strongly opposed to any practice by which tests are reported by the Experiment Stations may be adjusted by the Superintendent of Advanced Registry and that we urge the adoption of a system of automatic verification tests in connection with semi-official records, thereby increasing the official portion of the records rather than decreasing it as is the case under the present system.

It is recommended that in order to safeguard Experiment Stations and Agricultural Colleges from legal complications in vouching for Advanced Registry Testing that a statement setting forth the limits of the responsibility assumed should be stamped upon each report at the time the signatures of the Superintendent of Official Testing is affixed.

That Advanced Registry Testing should impose no financial burden upon the institution supervising such testing and that such institutions are justified in appropriating from the breeder for whom their testing is done the full expenses incurred including the full expenses of the supervisor.

That the Dairy Science Association ask the Holstein Friesian Association to either discontinue admission to the advanced registry on a seven day test or to extend that time which must elapse after freshening before the test is begun.

Moved by Eckles, seconded by Prucha that Part I of this report be adopted. It is understood that the committee will furnish the wording. Action. Carried.

Section II. Moved by Regan, seconded by Gamble that Section II be adopted as read. Action. Carried.

Section II was to be sent with proper explanations by the committee to Deans of Colleges and Heads of Departments.

Section III. Section III caused considerable discussion during which adjournment was made for lunch.

Meeting was called to order at 1.30 and discussion resumed on Section III of Eckles' report.

It was moved by Regan, seconded by Brant that the committee request the Association of Agricultural Colleges and Experiment Stations to be relieved of the responsibility of conducting all tests on all breeds of less than 300 days duration after October 1, 1920.

Section IV. Moved and seconded that the resolutions apply to all breeds. Carried.

Moved by White, seconded by Harding, that the committee on relation to breed associations be informed to present this matter to the Association of Agricultural Colleges and Experiment Stations.

After disposing of the report on relation to breed associations a report for the committee on milk quality was made by the chairman, Dr. Harding.

Mr. Gamble moved that this Association go on record favoring standardization of milk under proper supervision. (The composition to be stated on the label).

Remarks were made by Kelley of Washington and Professor Troy of Cornell. Action. Carried.

Dr. Harding's report follows:

Standardization of Milk

A part of the fascination of city milk problems arises from the fact that something new is always developing.

You are familiar with the minimum legal limits of milk composition which are in force in every state. You know that this form of legal enactment came into vogue when it was supposed that there was some natural limit below which milk would not go unless it was adulterated. You know that this idea is erroneous and that today a very considerable fraction of the milk of the country as it comes from the cow is illegal from the standpoint of these minimum legal standards. The most common deficiency is in "solids not fat," but occasionally one finds entire herds which are below the legal limits in both "fat" and "solids not fat." I think everyone conversant with the facts agrees that this illegal milk is an entirely wholesome and desirable food, its sole disadvantage being that it is not worth as much for food as an equal volume of a richer milk. Naturally, the milk producers who are selling this wholesome food just as it comes from the cow resent being branded as criminals. There has, accordingly, arisen on the part of the milk producers a widespread dissatisfaction with these dairy laws.

Following the unprecedented high price of milk the consumers are beginning to inquire regarding the food value furnished by milk. It develops that under the guise of milk they are liable to obtain an

article carrying anywhere from 3 per cent of fat and furnishing 546 calories per quart to one carrying 5 per cent of fat and furnishing 777 calories of energy per quart. They are interested in knowing a little more regarding the real value of the milk which they are buying at present high prices.

Until recently the milk dealers bought milk on the basis of weight and the composition was not a serious matter to them so long as it was above legal limits. Now milk is practically all purchased on the basis of fat content. While formerly the fat content did not enter into the cost price, now a variation of 0.1 per cent in the fat content of the milk purchased by a single company may mean as much as $100,000 per year.

These movements among the producers, handlers, and consumers of milk all have a common influence toward demolishing the old conception of milk as a substance of uncertain composition, and call for the recognition of milk or milks of definite composition to fit definite situations. In short, we are rapidly approaching the standardization of milk.

Standardization is a natural part of milk quality but because it has a number of angles and relationships I have hesitated to assume that it was a problem to be taken over by the committee on milk quality. I did, however, urge that the officers of the Association give the matter of milk standardization and milk standards consideration at the present meeting.

Your president has directed that it be taken up with the committee on milk quality, but as his instructions to this end did not reach me until last Saturday, time has not permitted consideration by the committee.

In attempting to get justice done, the milk producers who chance to have low testing cows, it seems fairly clear that little can be accomplished by attempting to have the present legal limits slightly lowered. Such action is not a solution for the real difficulty and brings one into sharp conflict with the representatives of the consumer who insists that the standards are now too low. Again, in the case of milk entering into interstate commerce, little can be accomplished unless a change is made in the laws of both states, as well as the federal regulations. This is manifestly a difficult undertaking.

Recognizing the magnitude both of the problem and of the difficulties involved, it has seemed best to strive for a concerted action on the part of the various interests involved. To this end the matter

is coming up in the various national bodies interested and later there will undoubtedly develop some satisfactory solution.

It seems fairly plain that if milk is sold for what it actually is, the situation will be fair to all concerned. It would seem that in the case of city milk this would lead to standardization and sale with an accompanying statement of the fat content and such other items as may be deemed necessary.

If this Association wishes to be a force in working out a better basis for milk standards than that at present in vogue, your committee on milk quality would like instruction or suggestions as to its future action with regard to this matter.

At this juncture Professor Van Norman came into the meeting and was asked to make a talk.

Professor Van Norman gave a résumé of the development of the dairy show and of the dairy association, stating something of the position of influence that it should occupy. In the course of his remarks Professor Van Norman presented his ideas of a world's dairy congress and urged the appointment of a committee to coöperate with other agencies to work on such a program.

Moved, seconded, and carried that a committee be appointed by the president to work with other agencies toward the end of making out plans for a world dairy congress.

Report called for on testing butter for fat.

A short verbal report was made by Professor Troy. Extensive remarks on this subject were made by Professors Bouska and Hepburn.

No action taken.

Report on Legal Standards for Butter presented by Professor Mortensen, Chairman. The report follows:

Report on Legal Standards for Butter

As this committee had already completed its most important work a couple of years ago, there is only a brief report to present at this time.

The question of butter standards is a very important one at this time. There seems to be a general tendency on the part of the public at present

to regulate the various industries and to demand that standards be fixed, especially for such important foods as dairy products. The members of the American Dairy Science Association welcomes these reforms. We consider that it is fair to consumers, producers, and manufacturers to adopt standards, if such are formulated, so they are fair to all concerned. No standard will be fair to the consumer or to the American dairyman or manufacturer, unless it is high enough so it will protect the quality of the American butter, but it is just as unfair to establish a standard so high so that it will be impossible for the American dairyman to comply therewith during certain part of the year.

We commend the work of the American manufacturers of dairy products. They are progressive and are not slow in adopting the modern methods in the process of manufacture, and wherever we go we usually find modern creameries operated by up-to-date butter makers. Compare today's creamery butter with butter made on the farm, and there is a remarkable contrast. Analysis made of farm dairy butter indicates that there is no uniformity in the product, the composition varying much with local conditions. It is to be regretted that only a very limited amount of data was available; more work would have been done at the Iowa State College had there not been a shortage of men in the Dairy Department.

The following analyses were made by the Dairy Department of Iowa State College of Iowa farm butter during the month of June, 1919:

DATE	MOISTURE	SALT	FAT
	per cent	*per cent*	*per cent*
June 19	12.5	2.49	81.75
June 19	22.1	2.23	75.25
June 19	16.85	3.47	79.00
June 19	18.75	2.85	75.75
June 19	17.35	1.48	76.25
June 19	15.0	0.69	82.25
June 20	10.9	6.13	80.00
June 20	14.45	0.80	82.75

The following analyses were made by Mr. W. B. White of Cornell University:

H_2O	NaCl	CASEIN
10.63	6.25	1.36
11.22	3.92	0.99
15.18	2.60	0.86
10.74	3.94	1.19
8.02	4.27	1.41
9.86	5.06	0.73
8.84	7.00	1.44
12.76	4.86	1.52
11.29	1.91	1.08
13.04	2.24	0.81
13.83	3.42	1.23
14.65	2.34	0.93
12.54	4.58	0.83

Moved by Professor Mortensen, seconded by Professor Lee that the report be adopted as read. Carried.

Moved we adjourn to meet at 7 p.m., Hotel La Salle, for our annual banquet. Carried.

A delightful banquet was served in the East Room, Hotel La Salle with about seventy in attendance. This was the largest banquet ever held by the Association. The principal address of the evening was given by Dean E. Davenport, Dean of the College of Agriculture, Urbana, Illinois. Following Dean Davenport's address the association listened to an informal talk relative to the future of the JOURNAL OF DAIRY SCIENCE by Professor Frandsen, editor of the JOURNAL.

Professor Erf, Chairman of the Committee on Cost of Production, then made a report which follows:

REPORT OF COMMITTEE ON COST OF PRODUCTION

A further development of the dairy business and the maintenance of an adequate milk supply is positively necessary for the development of man. Since milk is one of the most important foods and for which there is no substitute for developing health in children and maintaining the health of the adult, it is of the utmost importance that the supply be kept uniform and the price constantly at a level that will insure a supply of milk sufficient to provide for the demands of the increasing population and for the growing consumption that inevitably follows when people are educated as to its food value.

ECONOMICS OF MILK

If prices are too high, consumers are required to pay so much for milk that the consumption is consequently curtailed; production is unduly stimulated on the farm and whenever possible farmers will enter into production more extensively and will cease to supply the normal supply of other foods. This inevitably results in injury to the farmer who has made his plans with the idea in mind that the high price will continue.

On the other hand, it is possible for a time to hold the price so low that production will be curtailed. If the range between cost of production and the price received for a product is very great then a reaction usually follows in which the difference is in the opposite direction. The full effects of low prices are not immediately apparent, due to the fact that no costs are available and by the time that the haphazard producer realized the fact that he is suffering a loss, the intelligent dairyman has been forced out of business.

As a result, the dairy business will be demoralized to a considerable extent. Low prices result in the raising of a decreased number of heifer calves and consequently prevent the normal extension of the dairy business.

In the past the price of milk has been quoted in advance, for periods of a month or more. No feasible plan has been developed for selling milk on the daily market in the way in which grains are sold, and on account of the nature of the commodity, such markets are not likely to be developed. Since prices are quoted in advance, it is impossible to exactly foretell the supply or demand. Obviously the price of milk should be adequate to maintain a constant supply. The maintenance of the proper number of cows is more important than an excess or shortage of supply in any particular period, which may be too high or too low on account of the character of the season or other conditions.

The safest basis for forming a judgment as to what prices are necessary in order to maintain the number of cows that are necessary to furnish the required amount of milk continuously, is cost of production and we recommend that the price be made based upon costs for short time periods. Experience has shown that the monthly basis is the best as in no case should the contract be made to exceed three months.

COST OF PRODUCTION

It has been stated in the past that in discussing cost of production, the object in view should be clearly defined. There should be a distinction between the cost studies which have for their purpose arriving at the relative profitableness, with a view to obtaining a basis for choice on the part of the farmer, who has such an alternative, and those who have for their purpose the determining of what constitutes a fair price.

Within the past few years these conditions have brought on a feeling of mistrust on the part of a large number of milk commissions, food administrations and other public officials, in regard to the methods of figuring costs. While from the accountant's standpoint, farm cost studies may be theoretically more correct the practicalness of obtaining the figures frequently stands in the way. After all, the allocating of the various items might be incorrectly estimated unless the work is done by a competent man who can get true estimates and place a true proportional value upon each item. We therefore recommend that system of accounting be used, which may be termed "the departmental system" in which the dairy constitutes one department. For our purpose this should be given the chief consideration; although if other departmental accounts can be determined in addition, it will be exceedingly helpful in determining the relative incomes. For it might give the consumer an opportunity to see that the farmer while profiteering in one department was losing in another.

There are several methods by which dairy production costs may be determined: (1) the individual cow costs or the herd costs. While it is possible to separate herd costs from individual cow costs in some items, as a rule individual cow costs is the better method of securing cost of production.

These facts have been brought out in the cow testing associations and need not be mentioned here. It is for this reason that the cow testing associations have been converted into cost accounting associations, the latter differing from the former in that it includes labor as well as other costs in determining the profitableness of the cow and of the herd. Therefore, cow testing associations and cost associations might be inaugurated, and has been done in some instances. The combination makes a very practical and profitable method of obtaining accurate figures, and we submit it to you for your consideration, as to whether you will endorse this method of dairy cost accounting.

In figuring the cost of milk production with the individual cow cost accounting system, three accounts must be taken into consideration, namely: (1) the producing herd account; (2) the young stock account; and (3) when a bull is kept, a bull account.

The net cost of the young stock determines the proper valuation at which the heifers are placed in the inventory of the producing herd. In this case, when a calf is four days old, credit is given to the producing herd account and the calf is turned over into the young stock account. When this heifer grows to maturity and is producing milk the heifer is turned over into the producing herd account and given credit in the young stock account. In the same manner the bull service is charged to the cow. The net cost of keeping a bull divided by the number of cows determined the breeding charges per cow.

For the purpose of convenience and relative importance the selling price of milk should be determined at three points: (1) its value upon the farm, (2) its value at the country plant, and (3) its value in the city. Prices are determined by comparisons and it is unfair to make unequal comparisons, as is so frequently done under present conditions. Milk delivered in the smaller country towns may be delivered at a comparatively low price but still net the farmer more on the farm than when shipped to a large city. This oftentimes does the smaller city a great injustice; and the opposite may likewise be true. We, therefore, suggest that in cost accounting systems, the selling price be considered at two points at least—cost on the farm, the cost in the city, and whenever a county plant is used, a third cost should be given.

THE PRODUCING HERD ACCOUNT

The producing herd account is divided into two parts, the items relating to receipts and the items relating to expenditures. The expenditures of cost, minus the receipts or credits, will give the net cost of the milk sold.

1. Receipts. Under receipts are included milk and other dairy products, dairy products used upon the farm, calves, manure, hides, feed bags and other credits.

2. Expenditures. Expenditures are divided under three general heads—feed, labor and other expenses.

DETAILED DESCRIPTION OF PRESENTING DATA ON THE COST OF MILK PRODUCTION

Milk and other dairy products. Credit receipts for all sales. Note: Care must be taken that the credit is properly construed, depending upon the point at which the credits are paid. In most cases the credits are given at the point of distribution or in the city; however, in some cases they are paid at a point known as the country plant or receiving station. In a few cases they are paid at the farm.

Dairy products used at the farm. Credit the quantity of dairy products used at the farm. The price of milk at the farm, not including transportation, should be charged.

Calf. The value of the calf when four days of age should be credited to the herd account. Note: If a grade calf, the value should be the current price based upon slaughter value, depending upon the size of the calf and the breed, plus the value of the record of performance of the ancestors, if such records are available. If a pure bred, it should have pure bred value, depending upon the record of performance of the ancestors. In case the calf dies after it is one day old, credit for the hides should be given.

Manure. Credits for manure, according to the office of the Farm Management of the United States Department of Agriculture, manure ordinarily should be credited at $1.50 per ton, for the tonnage actually recovered, but owing to the increased price of commercial fertilizers during the war, manure may be charged at perhaps $2 per ton which would mean $2.75 in the field. However, no specific amount should be stated in this report as its value depends to a great extent upon the locality. The average cow voids about 56 pounds of manure a day and the amount recovered is that which is usually accumulated in the stables and in the yards.

Professor White of the United States Department, Chairman of the Committee on Students Judging Contest, made the following report which was adopted as read.

REPORT OF THE COMMITTEE ON METHODS OF CONDUCTING A STUDENTS' DAIRY PRODUCTS JUDGING CONTEST

Since the last contest was held two years ago, there has been under discussion the advisability of making some changes in the rules, and, after discussing the matter with various members of the dairy departments concerned, the following rules and changes are recommended:

1. This contest shall not be held unless three teams shall have been entered at the time specified in these rules.

2. In order that the contestants may know the standard used by the official judges, the latter shall select two additional samples of each product representing high and low quality respectively, and shall score and criticise these samples. The score and criticisms for each package of butter, cheese and milk shall be plainly written on a card signed by the judges and attached to the sample. These standard samples shall be available for examination by the contestants immediately before the contest.

3. In addition to placing scores upon the products, each student shall write his criticism or state his reason for the score given.

4. In determining the rating of the contestants, equal rating shall be given to the score and the criticism.

5. The butter shall be scored and criticised in accordance with the system outlined in Service and Regulatory Announcement No. 51 of the Bureau of Markets, U. S. Department of Agriculture.

6. The committee is authorized to devise a method of rating the criticisms on the products and make any minor changes in the rules that seem desirable.

Professor Frandsen, Chairman of Committee on Score Cards for Dairy Products, reported as follows:

First that the committee recommend that the American Dairy Science Association officially adopt the following score cards:

Cheese

	points
Flavor	45
Texture	30
Make-up	15
Color	10

Score cards for butter

	points
Flavor	45
Body	25
Color	15
Salt	10
Package	5
Total	100

Score card for cream

	points
Bacteria	35
Flavor and odor	25
Fat	20
Sediment	10
Acidity	5
Bottle and cap	5
Total	100

Relative to the score card for milk, the committee recommends that definite score cards as for milk be left open for study during the year, but in order that the dairy product coaches for the next students contest may have something definite on which to work, the committee recommends that for next year's contest the following score card be used as basis:

	points
Bacteria	35
Flavor and odor	25
Visible dirt	10
Fat	10
Solid, not fat	10
Acidity	5
Bottle and cap	5
Total	100

The committee does not feel warranted at this time in recommending score cards for ice cream, milk powder or condensed milk, but urges that the committee be continued and additional men be added to the committee and that during the coming year an especial study be made relative to score cards of these products.

Professor Frandsen moved that the committee's report be adopted. Motion duly seconded and carried.

Professor Lockwood, Amherst, was asked to prepare a report covering his studies of Dairy Departments of the country while he was with the DeLaval Separator Company. The report presented was adopted as read.[2]

[2] This report was published in vol. ii, no. 6 (November issue). JOURNAL OF DAIRY SCIENCE.—*Editor.*